Before the Hearing Commissioners
appointed by the Grey District Council and
West Coast Regional Council

Under	the Resource Management Act 1991
In the matter of	Resource consent applications by TiGa Minerals and Metals Ltd to establish and operate a mineral sands mine on State Highway 6, Barrytown (RC-2023-0046; LUN3154/23)

Statement of evidence of Graeme John Ridley

19th January 2024

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Qualifications and experience

1 My full name is Graeme John Ridley.

2 I am a Director of Ridley Dunphy Environmental Limited ("RDE"), an environmental consultancy that specialises in environmental management, in particular, erosion and sediment control, for a range of construction related projects.

3 I have the following qualifications and experience relevant to this evidence:

- I have a Bachelor of Agricultural Science from Massey University, Palmerston North (1986).

- I am a Certified Professional in Erosion and Sediment Control (CPESC Number 7629), a qualification that is achieved through Envirocert International and previously the International Erosion Control Association.

- Prior to forming RDE, I was employed as an environmental consultant with Environmental Management Services Limited. Prior to that I was employed by the former Auckland Regional Council ("ARC") in numerous roles including Manager of Consents and Compliance, Manager of the Land and Water Quality Team, and Manager of the Sediment and Stormwater Management Team.

- A particular focus of my career has been in the field of erosion and sediment control. I have over 30 years' experience in this area. I have a broad range of experience in erosion and sediment control, including detailed involvement for councils and the development community. I am responsible for the design and monitoring of erosion and sediment controls on a number of development sites throughout New Zealand.

- I have considerable experience in all aspects of earthworks, streamworks and stormwater activities. I have had intimate involvement with policy development and implementation, research, education and regulation covering all aspects of the development cycle.

- I have specific on-site experience and consenting experience with a number of earthwork projects including, but not limited to, Transmission Gully, Puhoi to Warkworth and Tauriko Business Estate. Having been directly involved with all erosion and sediment control aspects of projects I am aware of the issues, opportunities and practicalities with planning and onsite implementation.

- I was the primary author of the ARC Technical Publication Number 90 "Erosion and Sediment Control Guidelines for Land Disturbing Activities" ("TP90"), which was the primary tool promoted and used by the former ARC, and now Auckland Council, for the management of erosion and sediment associated with development sites. I was one of the authors and peer reviewers of the New Zealand Transport Agency Erosion and Sediment Control Standard for State Highway Infrastructure September 2014. I have had contribution into the development of the Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region June 2016 Guideline Document 2016/005 (GD05). My on-site experience has included significant implementation and interpretation of these guidelines and ensuring best practice and effective implementation.
- I am a past director and vice president of the Australasian chapter of the International Erosion Control Association.

4 My role in relation to TiGa Minerals and Metals Limited's (**TiGa**) application to establish and operate a mineral sands mine and associated activities at SH6 Barrytown (**Application and Application Site**) has been to provide advice in relation to erosion and sediment control.

5 My assessment is based upon the proposal description attached to the evidence of Ms Katherine McKenzie as Appendix 1.

6 In preparing this statement of evidence I have considered the following documents:

(a) the AEE accompanying the Application;

(b) submissions relevant to my area of expertise;

(c) the statement of evidence on prepared by Mr John Berry, Mr Tom Lawson. Mr Stephen Miller, Dr Gary Bramley, Dr Mike Fitzpatrick and Mr Jens Rekker.

(d) section 42A reports of West Coast Regional Council (**WCRC**) and Grey District Council (GDC); and

(e) draft conditions of consent dated January 2024.

7 I was engaged by TiGa in September 2022 in a capacity to develop an erosion and sediment control plan (ESCP) for the construction and mining aspects of the Application. I visited the application site on 15th March 2023.

8 My engagement since that time has included significant liaison with the Application team in particular that related to planning, mining construction and operation, ecology and hydrogeology.

Code of Conduct for Expert Witnesses

9 While this is not a hearing before the Environment Court, I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2023 and that I have complied with it when preparing my evidence. Other than when I state I am relying on the advice of another person, this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope of evidence

10 I have prepared evidence in relation to:

(a) the existing environment of the Application;

(b) the key findings of my assessment of effects;

(c) matters raised in the WCRC and GDC staff reports (reports issued under s42A of the RMA); and

(d) proposed conditions of consent.

The existing environment

11 The Application site is currently used for dairy farming and is considered a highly modified humped and hollowed parcel of farmland located adjacent to SH6. The site has some wetland features bordering the site to the south and west, a small unnamed manmade drainage channel on the northern boundary, and Collins Creek on the southern boundary. There are springs on the adjacent property to the south of the site utilised for domestic and stock water supply. An artificial watercourse has been previously established through the central portion of the site and is referred to as the Central Drain.

12 Two thirds of the Barrytown Flats are underlain by O'Keefe Formation muddy sandstone and the southern third is underlain by Karamea granitic basement. Granite Creek and Little Granite Creek have their headwaters in the Karamea granitic batholith rocks. The Barrytown creeks north of Canoe Creek have their headwaters in softer, more erodible O'Keefe Formation sandstones.

13 The mineral sands that are the focus of this Application comprise post-glacial coastal sand and gravel deposits. The mineral sands are considered to have been set down in a series of north – south trending prograding strand lines. The sediment

supply for deposition of the sands is inferred to have been long-shore drift from the south.

14 Groundwater throughout the flats is fresh with low dissolved salts content including along the coastline. This suggests the aquifer is fully flushed with fresh water recharged from rainfall excess and creek infiltration. Groundwater flows relatively slowly and weakly through the mineral sands, tending to follow preferential pathways within sandy gravel. The main groundwater hydraulic gradient is from the eastern reaches of Collins Creek and soil drainage to seepage emergence in wetlands and coastal lagoons.

15 Additional recent geological and hydrological investigations for the Application have resulted in a significant revision in the hydrological concept and a revised groundwater computer modelling exercise. The key findings from this work were:

- Collins Creek and Northern Boundary Drain were less connected to the groundwater system affected by mining,
- Deeper drilling found that the previously assumed thick basal gravel was a thin veneer and the deep subsurface was primarily sand of low permeability, and
- 24-hour pumping of deeper groundwater layers suggested that the water that would be drawn into the mine pit ponds would be different from existing monitoring of shallow groundwater and be lower in dissolved metals such as copper and zinc.

16 Based on the knowledge of the receiving environment and the extent of the works, while the Application works are assessed as low risk due to soil types and flat grades it is important that the minimisation of discharges from the Application activity occurs at all times. It is also important to recognise, and account for, that due to frequent heavy rainfall at the Application Site, streams in the area can experience high turbidity events, and that following these events water returns to low turbidity relatively quickly.

17 From a water management perspective, in particular during the mining phase of the Application, the risk is increased due to groundwater infiltration, in particular the volumes of groundwater that are expected to be encountered. Groundwater infiltration will therefore be a key consideration and best practice erosion and sediment control measures need to be designed, implemented and maintained with a BPO approach to ensure appropriate environmental outcomes can be achieved overall.

18 Recent investigation has confirmed that the main implication for erosion and sediment control is that pumping of groundwater from pit ponds will decline from a

previous average rate of 90 L/s to 30 L/s, while peak rate would drop from 203 L/s to 68 L/s. This is a substantial decrease in terms of the water that needs to be managed.

19 While the investigations have confirmed a decrease in the groundwater infiltration rates, the proposed treatment pond designs have not been amended and remain at the original large capacity. This is discussed further below and is noted to assist with a subsequent decrease in environmental risk due to lower volumes of water requiring treatment and a large volume of treatment device capacity resulting in a more effective treatment and therefore overall a reduced discharge volume.

Earthwork activities

20 My assessment for the erosion and sediment control is based on 2 specific phases of the Application referred to as construction and operation. I was the primary author of the Erosion and Sediment Control Plan (ESCP) that supports this approach with this ESCP having a primary focus on the set up and construction phase of the Application with the operational mining phase also included but also assessed by others, in particular Mr Tom Lawson and Mr Stephen Miller.

21 The ESCP has been updated in January 2024 to incorporate and reflect the various peer review outcomes, submissions and the Council reports received. This ESCP (January 2024) supersedes all other ESCP versions and is attached to this evidence as Annexure A.

22 The ESCP provides the overarching approach to water management on site and is based on the provision of a detailed Site Specific ESCP (SSESCP) to be established pre works which will include specific design details and will also provide the ability for the various parties to have further input into the methodologies implemented to ensure enhanced outcomes and the opportunity for other innovative practices to be implemented.

23 The SSESCP will be reviewed annually and submitted with the Annual Work Programme, reflecting the water management measures proposed for construction and mining for the following 12 months.

24 The SSESCP will primarily be based upon the principles detailed within the ESCP and will reconfirm the methodologies and construction sequence to be followed. The benefits of allowing this management plan approach to be confirmed at implementation time is to ensure ongoing innovation and flexibility remains and enables the Application team and the consent authority to have further input into the methodologies implemented.

25 The ESCP confirms the content that will be included within the SSESCPs to be developed.

26 For the purposes of this assessment the proposed construction sequence and specific earthwork activities are all documented within Annexure B of this evidence. This provides specific locations, areas, volumes, discharge locations and ESC measures to be implemented.

Erosion and sediment control approach

27 The ESCP contains a series of principles that confirm the following:

- ESC measures will be based on a range of structural (physical measures) and non-structural (methodologies and construction sequencing) measures.
- ESC measures will, where practicable, meet the minimum criteria as detailed in this ESCP and will incorporate innovative ideas and procedures to ensure best practice applies and to match any local challenges and opportunities.
- Progressive and rapid stabilisation of disturbed areas (including using mulch) will be on-going during the mining activity. Any stabilisation alternatives (not outlined within GD05 Guideline) will first be verified as an appropriate and WCRC authorised stabilisation media.
- Stabilisation will need to be appropriate to the soil surface geology with the intent of achieving an 80% vegetative cover or non-erodible surface over the exposed area. Stabilisation is designed for both erosion control and dust minimisation and will be progressively implemented.
- A monitoring and management approach which allows a response to water quality (turbidity and other contaminants) monitoring outcomes will be utilised for the mining activity through qualitative monitoring (which will include visual surveys and recording of any discharges and the downstream environment) and quantitative monitoring (which will include water quality sample collection and analysis).

28 In terms of construction activities, the ESCP details the various ESC measures that will be implemented. These activities are also to be addressed in full through the SSESCP process and are subject to the principles and practices as outlined within the ESCP.

29 A maximum of 8.0ha of land will be exposed at any one time through the construction and operation of the Project.

30 Stormwater generated in the processing plant area will be captured and directed to settling ponds via pumping to the treatment ponds (referred to as Ponds 1 and 2) before treated water discharges to the central drain which will convey discharged water from the mine water facility and Wet Concentration Plant (WCP) to finishing ponds (Ponds 3 and 4) in the north-western corner of the property.

31 Water from the mining void and stormwater runoff from the process plant area will also be diverted or pumped to Pond 1 and Pond 2. Pond 1 includes two separate forebay impoundments which are designed to capture most of the sediment prior to flow into the main body of Pond 1 and then over a level spreader to Pond 2. Where sediment laden water will enter the Pond 1 forebay a flocculant may be added to the water to assist with sediment settlement.

32 Maintenance of the Pond 1 forebays will be ongoing to ensure capacity remains as best practicable at all times. While 1 forebay is subject to maintenance the other forebay will be utilised. If required, the main body of Pond 1 will also be subject to maintenance clean outs. Pond 2 can also be subject to maintenance clean outs however this is not expected or will be infrequent.

33 The clean water from Pond 2 will then discharge via a pump to the Mining Unit Plant (MUP) or WCP for use in the process plants with excess water at the WCP pumped to the central drain. The central drain has a series of rock check gabion dams installed and these will assist with flow reduction and also will capture some sediment over time.

34 The central drain will flow to a finishing pond and the clean water facility (referred to as Ponds 3 and 4) in the southwestern corner of the property. Excess water from Pond 3 will overflow (or be pumped) into the clean water facility (Pond 4) before discharging to the environment.

35 Excess water from this finishing pond will be directed to infiltration trenches in the first instance to recharge groundwater and avoid surface water depletion. This will be supplemented by injection wells where required[1]. Whatever water that cannot be directed to infiltration trenches will be discharged from the finishing pond into the drain which discharges to Canoe Creek Lagoon if water quality and clarity allows.

36 If the mining phase water quality or clarity parameters as specified within the consent conditions are not met, the discharge water will be managed, in order of preference as below. In addition, as per the evidence of Mr Tom Lawson, a clarifier with associated flocculation can also be implemented to treat all mine water discharges, via the WCP process water systems, to the necessary mining phase water quality standards included in consent conditions:

i. The water will be recirculated into the processing plant and mine water facility if there is capacity in the system;

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[1] Addressed in the evidence of Mr Rekker

ii. Excess water will be pumped to the Canoe Creek infiltration basin. In extreme circumstances (i.e. a 1 in 10-year flood event), water that does not infiltrate through the basin will be discharged to a swale, which discharges to the floodplain of Canoe Creek at the river mouth;

iii. Recharge barrier wells may also be employed as a fallback option to maintain groundwater levels; and

iv. As a last resort, or in extreme weather events, processing can cease and the mine pit can be flooded to provide significant additional containment and settling capacity and allow groundwater levels and stream flows to recover. This would provide time to resolve issues before recommencing discharge.

37 The Application has committed to having a maximum area open at any one time of 8.0ha. This includes all the bund establishment and road access provisions. This has the effect of ensuring, including through site establishment phases, that progressive stabilisation is implemented and the risk of sediment generation and discharges are greatly reduced.

38 As detailed above in Paragraph 36 the clarifier system will be purchased and positioned on site from mining commencement to ensure that if such a system is demonstrated to be required then commissioning can occur within a very short timeframe.

39 For the mining phase, mining will progress in strips, with a dimension of 100m wide (strip width) and 300m long.

40 Mining will commence in the southwest of the area and progressively moves eastwards on 100 wide strips/panels. Each subsequent strip of mining is located north of the previous strip, with the exception of Panel 9, which is located in the southwestern most extent of mining. Mining along each strip is always from the west to the east.

41 20m mining setbacks will apply to the northern and southern property boundaries, Collins Creek and the coastal lagoon area. The area south and west of Collins Creek is also excluded from the mining area.

42 The ESCP includes details of all ESC measures to be implemented. This includes the provision of bunds, silt fences, super silt fences, progressive stabilisation and a range of best practice ESC measures. As noted above these will be fully documented, designed and confirmed within the SSESCP to be established pre works.

43 Final rehabilitation of the Project will include returning the land back to agricultural land use. This is to all occur within the mining disturbance area and will have the following general sequence.

- As the mine progresses there will be ongoing rehabilitation with the land returned to final landform and a stabilised surface. There may be some final shaping at the end of the Project life to ensure the contours “marry into”” the surrounding landform.

- Any areas outside the mining process that are not subject to progressive rehabilitation will be subject to rehabilitation as a separate activity. This will be humped and hollowed to be consistent with the progressive rehabilitation area. This may include some borrow material for the final panel progressive rehabilitation and to ensure the western extent of the Project maintains its original height above sea level in its final form.

44 This rehabilitation outside of the mining sequence will remain subject to the SSESCP process and it is expected this will be managed through the provision of topsoil bunding, working within the open area restrictions and progressive stabilisation.

Monitoring

45 An adaptive monitoring programme will be implemented for the Application. This monitoring programme will involve ongoing site monitoring to check that the ESC water management measures have been installed correctly and that methodologies are being followed and are functioning effectively throughout the duration of the works. This will also directly inform the AWP for the Application. This is a typical best practice approach that is implemented on many earthwork projects.

46 Monitoring results that eventuate, as defined below, will also be used to identify future risks to the environment and will identify any continuous improvement opportunities that should be considered by the construction team.

47 The monitoring programme will include risk assessment to determine what further measures are required to reduce construction discharges. The adaptive monitoring will include a continual feedback loop until it has been verified that the implemented responses have been successful in minimising discharges from the Project construction.

48 Visual assessments of the receiving environment will be undertaken regularly throughout the works period with particular attention paid before, during and after periods of rainfall. In the context of visual assessment, the receiving environment

is defined as the infiltration trench and any discharges to surface water including the downstream coastal lagoon.

49 This monitoring will include visual observations of all pond outlets, all pump discharge locations, the central drain and the receiving environment. This will occur a minimum of once per day and also after rainfall with a record kept of these inspections.

50 Weather forecast monitoring will form an important part of the Application implementation to ensure that these higher risk periods are proactively managed appropriately.

51 As part of the mining phase for the Application, and as documented within the proposed conditions of consent, quantitative sampling for sediment discharge will occur and will include:

- Automated continuous sampling for turbidity at the discharge from Pond 2;
- Automated continuous sampling for turbidity at the discharge from Pond 4;
- Manual sampling for turbidity using field meters or grab samples on a weekly basis within the Central Drain upstream of the mining activity;
- Manual sampling for turbidity using field meters on a weekly basis within the Central Drain immediately prior to Pond 3; and
- Other manual grab water quality sampling of turbidity and total suspended solids on a SSESCP basis dependent upon the activity and the discharge location. This shall include upstream and downstream sampling of discharges during the construction activities.

52 While no specific discharge water quality standards are recommended within this ESCP for the short-term construction activities it is assessed that reliance on the details within the ESCP and the future SSESCP process remains as the best practice and effective approach. Utilisation of field turbidity meters during this construction phase can also be implemented to assist with understanding of any water quality changes over that short period.

53 For the mining phase activities and associated discharges, specific water quality and clarity standards are proposed within the consent conditions and are assessed by others.

Assessment

54 The following key points are noted for the Project.

- Land disturbance activities associated with the construction phase are short term and will be managed with ESC measures that are compliant with GD05 Guideline.

- Due to the controlled nature of the mining phase works and the staged approach and progressive stabilisation of rehabilitated areas, the risk of erosion and consequential sediment discharges is low.

55 The highest risk of sediment discharge is a result of the groundwater infiltration that may result. This infiltration rate will be variable and will be managed appropriately through the proposed water management systems. Groundwater infiltration rates (and consequentially volumes) are lower than originally assessed and treatment device capacities have remained as previous. This results in a larger (than design) treatment volume capacity which with the various design details (as per the ESCP) and back up provision of a filtration device, results in an effective treatment approach.

56 A range of ESC and water management measures are proposed on the Project that meet the GD05 Guideline criteria or provide an alternative best practice measure. ESCs will be based on both structural and non-structural measures with emphasis placed on the non-structural management techniques.

57 An adaptive monitoring programme will be implemented which will allow for ongoing continuous improvement of the ESC and water management measures and will allow for annual reporting and adaptations all detailed within the AWP. The monitoring regime includes construction phase qualitative monitoring and also specific quantitative monitoring for the mining phase of the Project.

58 I assess that the proposed erosion and sediment control measures are appropriate for the nature of the activity, climate and receiving environment at the Application Site. I assess that with implementation of the process as described within the ESCP and confirmed through the consent conditions, that a best practice and an effective approach to erosion and sediment control will occur and any associated effects will be less than minor.

Matters raised by WCRC and GDC staff reports

59 The GDC s42A Officers report refers to erosion and sediment control and confirms[2] that they consider that erosion and sedimentation effects are primarily effects on water quality and therefore within the jurisdiction of the WCRC. The exception to this is dust effects and sedimentation of roads.

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[2] Paragraph 204

60 In paragraph 212 GDC confirm that the ESCP *"makes it clear that suitable measure are in place to avoid sedimentation on road. No submissions have raised sedimentation of the road as an issue. I note that Section 1.5 of the erosion and sediment control states that it will be continually reviewed. With these matters in mind, I consider that sedimentation effects on the road will likely be less than minor."*

61 In paragraphs 213 to 221 GDC assess the details of the dust management plan as provided for the Application Site. My experience with dust management on earthwork activities is that it is relatively easy to manage with the provision of an appropriate water supply and water application ability (such as a water cart). The Application Site is largely a "wet operation" and further application of water with water carts can easily be implemented if required. These aspects will ensure minimisation of dust generation and discharges.

62 While I am not a primary author of the Dust Management Plan, I have reviewed the content and I confirm from my experience elsewhere that the approach of having a Dust Management Plan with supporting consent conditions is an effective approach to dust management and will achieve the necessary outcomes if implemented accordingly.

63 I provide no comment on the WCRC Officers report.

Proposed consent conditions

64 I confirm that I have had input into the development of consent conditions which relate to erosion and sediment control, including water quality parameters and monitoring requirements.

65 I confirm that the proposed conditions of consent will ensure implementation of the necessary erosion and sediment control measures and will ensure sediment and associated discharges are effectively managed on site such that effects are less than minor.

66 In particular I note the requirement to operate in general accordance with the ESCP and prepare a SSESCP to confirm the approach and compliance with the principles and practices as detailed within the ESCP[3]. The conditions further specify the objectives of the ESCP and the content of the SSESCPs. These conditions provide the certainty necessary to ensure effective operation and implementation of the ESCP process.

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[3] Proposed conditions 23.1 and 23.2

67 I further note the condition[4] related to a maximum open area of 8.0ha at any one time and that this in itself promotes progressive stabilisation, effective staging and sequencing of works. This aspect of erosion and sediment control is recognised within the industry as a primary factor in achieving effective outcomes. I confirm that this will ensure that sediment generation and any subsequent discharges are minimised for the Application.

Conclusion

68 Overall, I assess that in the context of erosion and sediment control, the ESCP and the proposed conditions of consent, into which I had input, allow for flexibility for the contractor to implement the Application, while providing certainty that effects of the Application can be managed appropriately. These conditions include the development of a future SSESCP that will allow for innovation and amendments as necessary in response to the previous 12-month period of activity and monitoring outcomes.

69 In addition to specific practices and methodologies, the ESCP outlines the comprehensive monitoring that will occur to ensure that erosion and sediment control measures and methodologies are fully effective and remain this way.

70 My experience in erosion and sediment control confirms that the Application is proposing a best practice approach with effective structural and non-structural measures. Overall, I conclude that the effects of sediment discharges from the Application will be less than minor.

Graeme John Ridley
Dated this 19th day of January 2024

[4] Proposed condition 21.2

RidleyDunphy
environmental & planning consultants

Barrytown Mineral Sand Operation

Erosion and Sediment Control Plan

TiGa Minerals and Metals

Ridley Dunphy Environmental Limited
17th January 2024
Final - Version D

Document title:	Barrytown Erosion and Sediment Control Plan
Version:	Updated Version - Rev D
Date:	17th January 2024
Prepared by:	Graeme Ridley, RDE Limited
Reviewed by:	RDE Limited
File name:	Barrytown Erosion and Sediment Control Plan Final

TiGa Minerals and Metals Limited

Quality Assurance Statement			
Prepared by:	G.J. Ridley	Graeme Ridley	Ridley Dunphy Environmental
Approved for release:	G.J. Ridley	Graeme Ridley	Ridley Dunphy Environmental

Revision schedule		
Rev. Number	**Date**	**Description**
A	10th February 2023	Draft for Project Review
B	28th March 2023	Final Draft
C	31st March 2023	Final Review
D	17th January 2024	Updated re Construction

Glossary of terms

Report relevant terms	Definition
Earthworks	The disturbance of land surfaces by blading, contouring, ripping, moving, removing, placing or replacing soil or earth, or by excavation, or by cutting or filling operations.
Erosion control	Methods to prevent or minimise sediment generation, in order to minimise the adverse effects that land disturbing activities may have on a receiving environment.
Land disturbing activity	Any disturbance to the ground surface that may result in soil erosion through the action of wind or water.
Sediment control	Capturing sediment that has been eroded and entrained in overland flow before it enters the receiving environment.
Sediment generation	That sediment that is generated on the site of earthwork activity prior to treatment through any sediment retention device.
Sediment load	Mass of sediment carried in suspension within rivers and marine waters.
Sediment retention pond	A detention structure that is used during the construction phase of earthworks activity to treat any sediment laden runoff and retain sediment.
Sediment yield	That sediment which leaves the sediment retention devices and enters the receiving environment can be expressed in many ways including suspended sediment concentration or a mass load on a time basis or an aerial basis.
Stabilisation	An area inherently resistant to erosion such as rock, or rendered resistant by the application of aggregate, geotextile, vegetation, mulch or an approved alternative. Where vegetation is to be used on a surface that is not otherwise resistant to erosion, the surface is considered stabilised once an 80% vegetation cover has been established.

Glossary of abbreviations

Report relevant abbreviations	Definition
AWP	Annual Work Programme
BPO	Best practicable option
ESC	Erosion and sediment control
ESCP	Erosion and sediment control plan
GD05 Guidelines	Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland region. June 2016 incorporating Amendment 2 (February 2020).
HMC	Heavy Mineral Concentrate
SF	Silt fence
SRP	Sediment retention pond
SSF	Super silt fence
WCP	Wet Concentrator Plant
WCRC	West Coast Regional Council

Contents

1. Introduction

1.1 Purpose and scope of this report

This Erosion and Sediment Control Plan (ESCP) is prepared in support of land disturbance and associated mining activity relating to a proposed mining operation for ilmenite, garnet and other minerals over an area of approximately 63ha (covered by Mining Permit MP 60785) at Barrytown, Westcoast of South Island, New Zealand. Within this ESCP the overall mining operation is referred to as the Project and is shown within Appendix A of this ESCP.

This ESCP supports the Project and confirms the overall approach to erosion and sediment control (ESC) and associated water management during the mining operation. This ESCP has a primary focus on the set up and construction phase of the Project with the operational mining phase also included but also assessed by others. It is noted that there are "cross overs" between these 2 phases with these addressed as necessary within this ESCP.

This ESCP has been updated in January 2024 to incorporate and reflect the various peer review outcomes, submissions and the Council reports received. This ESCP (January 2024) supersedes all other ESCP versions.

1.2 Erosion and sediment control and SSESCP development process

Our assessment of the ESC and practices likely to be required for the Project is based on the detail within this ESCP and also the supporting information supplied as part of the overarching consent application. This ESCP outlines the principles that will need to be applied throughout the adopted approach for all construction activities and associated water management.

As the Project works have the potential to result in sediment yields downstream, the focus during earthworks remains on best practice erosion and sediment control implementation.

This ESCP provides the overarching approach to water management on site. Prior to any work activity a detailed Site Specific ESCP (SSESCP) will be established for the Project which will include specific design details and will also provide the ability for the various parties to have further input into the methodologies implemented to ensure enhanced outcomes and the opportunity for other innovative practices to be implemented. The SSESCP will be reviewed annually and submitted with the Annual Work Programme, reflecting the water management measures proposed for construction and mining for the following 12 months. This will provide the detailed design, specific ESC measure location, staging and sequencing of works for that location. The SSESCP process will determine specific measures to be employed and, in this regard, will consider the alternatives that exist. It will take into account the various environmental and ecological values and will then determine the most effective and appropriate form of ESC devices and management practices required to manage erosion and sediment control. The likely content of the SSESCP is confirmed in Section 1.4 below.

The SSESCP will primarily be based upon the principles detailed within this ESCP and will reconfirm the methodologies and construction sequence to be followed. The benefits of allowing this management plan approach to be confirmed at implementation time is to ensure ongoing innovation and flexibility remains and enables the Project team and the consent authority to have further input into the methodologies implemented. For the purposes of this assessment the proposed construction sequence and specific earthwork activities are all documented within Appendix A of this ESCP.

In addition, this ESCP confirms a monitoring programme that will be implemented throughout the construction earthworks and mining activity that will inform and adapt future activities and water management approaches. This monitoring programme will form a key component of an Annual Work Programme (AWP) which will apply to both construction and mining phases and will confirm the outcomes from the previous 12 months and confirm the approach for the upcoming 12-month period.

Some amendments to the water management approach may be determined through the AWP once works commence and these will be discussed and documented on site with West Coast Regional Council (WCRC) as necessary.

Figure 1 below confirms this management plan approach.

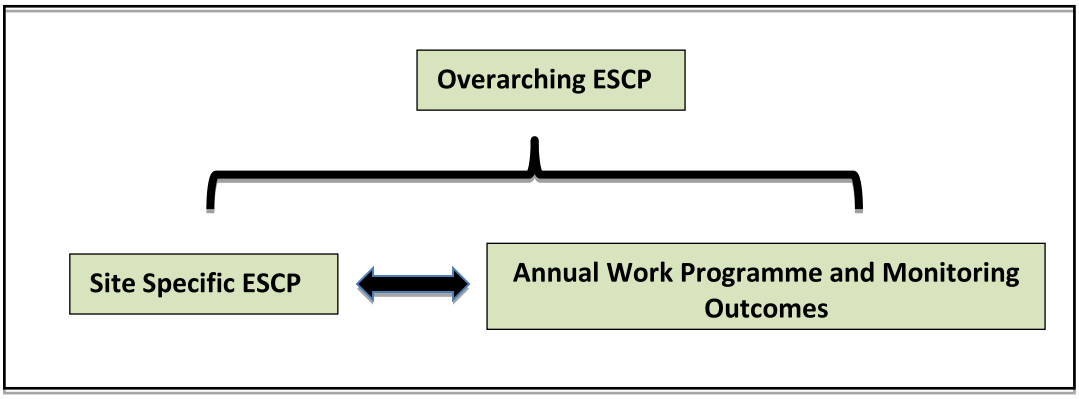


Figure One: ESCP Management Plan Approach

1.3 Project description and features

The Project site is currently used for dairy farming and is considered a highly modified humped and hollowed parcel of farmland located adjacent to State Highway 6 (SH6). The site has some wetland features bordering the site to the south and west, a small unnamed manmade drainage channel on the northern boundary, and Collins Creek on the southern boundary. There are springs on the adjacent property to the south of the site utilised for domestic and stock water supply. An artificial watercourse has been previously established through the central portion of the site and is referred to as the Central Drain.

The only vegetation other than pasture on the site is a small area of flax which has been planted as a wind break around a stock run off pad in the middle of the site. Watercourses have not been fenced from stock and other than limited riparian planting for a small section of Collins Creek, the banks of waterbodies are unstable and subject to erosion due to stock access and lack of vegetation. A photo of Collins Creek and the Central Drain is included below.

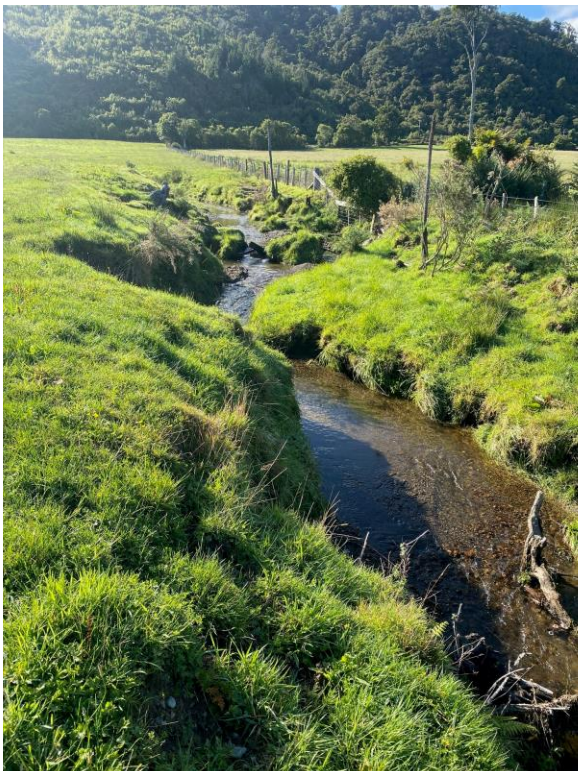


Plate One: Collins Creek South Eastern Extent

Plate Two: Central Drain

The construction activities are described below and the mining activity itself generally includes removal of topsoil and excavation of mineral sands by an excavator, which will be pumped to the onsite processing plant. Specifically:

(a) Topsoil, approximately 0.2- 0.6m thick, and overburden will be removed and stockpiled for rehabilitation using an 85 tonne excavator, and 40 tonne articulated trucks. Once in mining sequence, topsoil will be removed ahead of mining and placed straight onto rehabilitated ground behind the mining pit.

(b) The sand ore will be mined via excavator and deposited onto a mining bench. The ore will then be picked up by frontend loader directly to the in-pit mining hopper. Maximum mining depth will be 9m.

(c) The slurry will pass through a trommel and desliming circuit before being pumped to a Wet Concentrator Plant (WCP). Reject large material from the trommel and slimes will be returned to the mine pit. Heavy minerals will be separated from the ore using a water and gravity circuit, drained of excess moisture and stored at the processing plant in a covered building.

(d) Excavated material will be processed at the processing plant to extract the Heavy Mineral Concentrate (HMC). Un-mineralised sands will be pumped back to the pit cavity where a cyclone will be used to remove the water from them before they are discharged to the mining void, which will be progressively filled as the mine pit progresses.

Actual mining is expected to take approximately 5-7 years to full stabilisation based on an extraction rate of 1,100,000 tonnes per year with a total 4,800,000 tonnes of recoverable sand ore within the mining area.

Figures 2 and 3 below show the general project location.

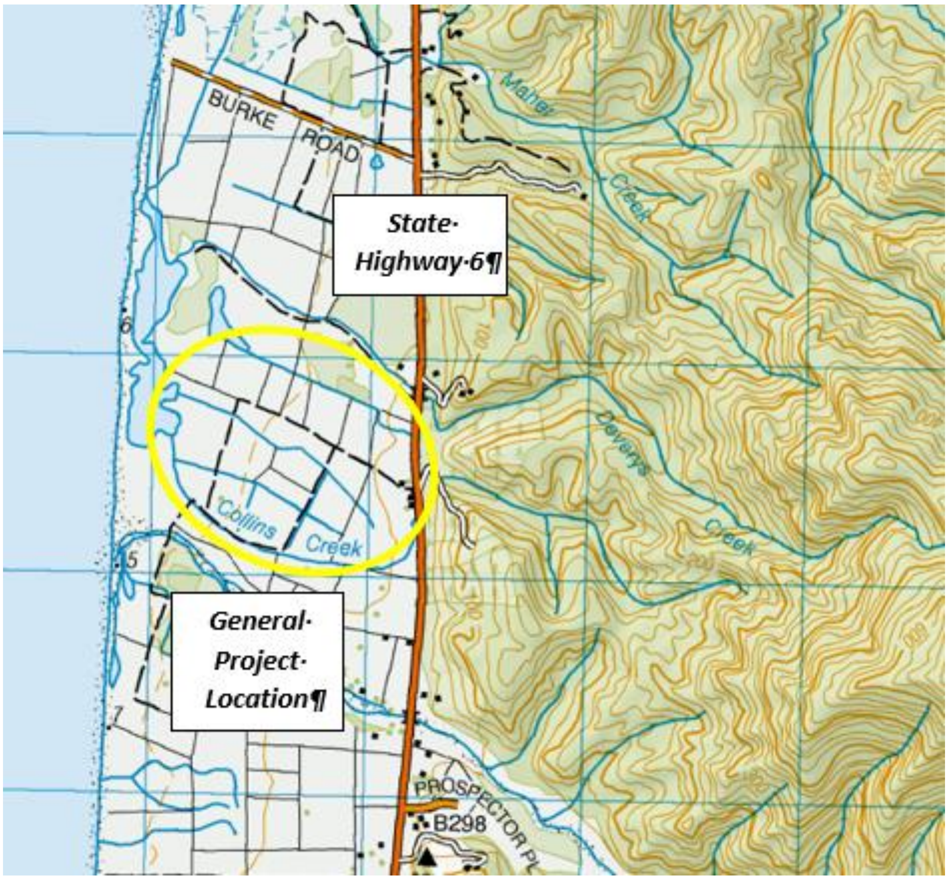


Figure Two: General Project Location

Figure Three: Project Aerial and Watercourse Features

The project description provided with the application confirms the processing plant requirements and general arrangement.

1.4 ESCP content and project specific construction activities

As part of the development of this ESCP, consideration has been given to WCRC expectations with respect to the erosion and sediment control design and ESCP content. The concepts of this ESCP have been discussed with WCRC and generally confirmed as appropriate. Importantly the principles and practices from within Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region. June 20016 incorporating Amendment 2 (February 2020) (GD05 Guidelines) have been applied.

This ESCP therefore has been developed with consideration of the following detail:

a. Details of all principles, procedures and practices that will be implemented to minimise the potential for sediment discharge from the site;

b. The design criteria, supporting calculations, dimensions and contributing catchments of all key ESC and water management structures, including (but not limited to) diversion bunds/channels and impoundment structures;

c. Works timetable and sequencing for the proposed mining activity;

d. Timetable and nature of progressive site rehabilitation and re-vegetation proposed;

e. Maintenance, monitoring and reporting procedures; and

f. Rainfall response and contingency measures including procedures to minimise adverse effects in the event of extreme rainfall events and/or the failure of any key ESC structures.

The works timetable and sequencing for the proposed mining activity is addressed in the reporting of Mr Tom Lawson, Royal IHC Mining and Mr Stephen Miller, mining engineer from Palaris. Appendix A of this ESCP also includes the construction sequence and earthworks details.

As detailed above there is reliance on a SSESCP process with the likely content of this SSESCP as follows.

- Location of the work;
- Contour information;
- ESCs;
- Chemical treatment requirements, design and details;
- Catchment boundaries;
- Details of construction methods;
- Contingency measures;
- Design details;
- A programme for managing non-stabilised areas;
- The identification staff who will manage ESCs;
- The identification of staff who monitor compliance with conditions;
- A chain of responsibility for managing environmental issues; and
- Methods and procedures for decommissioning measures.

1.5 Roles and responsibilities

TiGa as the consent holder will have the overall responsibility for meeting the requirements of this ESCP. The contractors and sub-contractors whom are yet to be formally engaged and will be located on site, will include an environmental manager (or equivalent) that will implement this ESCP (and subsequent SSESCPs) including all required monitoring, management and necessary communication to the regulatory agencies including WCRC.

This ESCP and the SSESCP will be implemented for the duration of the construction activity, and where relevant the mining works, and a copy will be kept in an accessible location for the duration of the Project.

This ESCP and SSESCP will also continually be reviewed during works and will be subject to amendments as necessary in consultation with WCRC as part of the AWP process.

2. Existing environment

2.1 Rainfall

Punakaiki is reported to experience approximately 2800mm rainfall per year, with the rainfall relatively consistent throughout the year. Figure 4 below illustrates this rainfall pattern which is assessed to be similar for the Project site. On average October is the wettest month and February is the driest month.

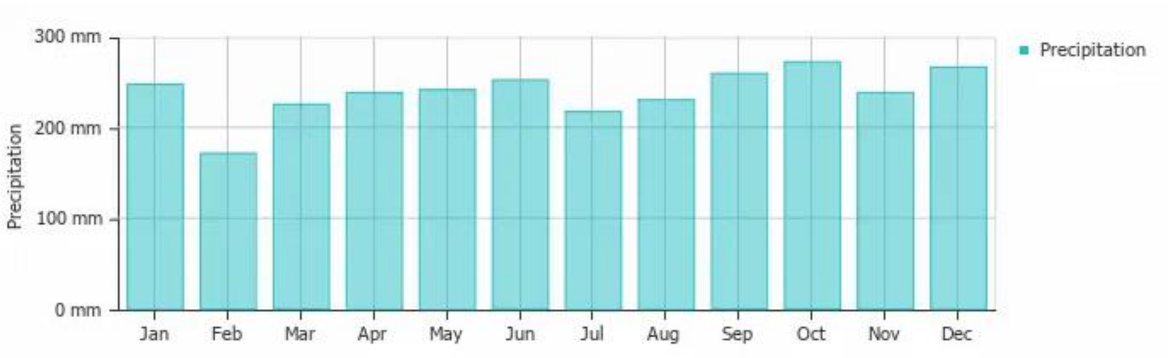


Figure Four: Punakaiki Annual Rainfall Patterns

2.2 Geology and hydrology

Two thirds of the Barrytown Flats are underlain by O'Keefe Formation muddy sandstone and the southern third is underlain by Karamea granitic basement. Granite Creek and Little Granite Creek have their headwaters in the Karamea granitic batholith rocks. The Barrytown creeks north of Canoe Creek have their headwaters in softer, more erodible O'Keefe Formation sandstones.

The mineral sands that are the focus of this Project comprise post-glacial coastal sand and gravel deposits (Suggate, 1989). The mineral sands are considered to have been set down in a series of north – south trending prograding strand lines. The sediment supply for deposition of the sands is inferred to have been long-shore drift from the south.

The hill backdrop to the Barrytown flats is dissected by 17 individual stream and creek catchments. Canoe Creek is the largest of these and has headwaters at the Paparoa Range crest. Granite Creek and Fagan Creek are the main catchments draining the face of the coastal range south of Canoe Creek and adjacent to the Barrytown settlement.

There are several springs along the southern boundary of the Project area which are used by the neighbouring landowner for stock water and for water tank top-up in dry weather. In addition, a coastal lagoon known as Canoe Creek lagoon is located on the western border of the Project site. The lagoon receives water from Collins Creek and Deverys Creek towards the centre and from Maher Creek to the north. The creek is also likely to be recharge via groundwater seepage.

Groundwater throughout the flats is fresh with low dissolved salts content including along the coastline. This suggests the aquifer is fully flushed with fresh water recharged from rainfall excess and creek infiltration. Investigations have confirmed there is mixed grain size alluvium in the east of the Project that peters out to the west and is largely absent at the eastern margin of the proposed sand extraction operations area. Groundwater flows relatively slowly and weakly through the mineral sands, tending to follow preferential pathways within sandy gravel. The main groundwater hydraulic gradient is from the eastern reaches of Collins Creek and soil drainage to seepage emergence in wetlands and coastal lagoons.

Additional geological and hydrological investigations for the Project have resulted in a significant revision in the hydrological concept and a revised groundwater computer modelling exercise.

The key findings from this work were:

- Collins Creek and Northern Boundary Drain were less connected to the groundwater system affected by mining,
- Deeper drilling found that the previously assumed thick basal gravel was a thin veneer and the deep subsurface was primarily sand of low permeability, and
- 24 hour pumping of deeper groundwater layers suggested that the water that would be drawn into the mine pit ponds would be different from existing monitoring of shallow groundwater and be lower in dissolved metals such as copper and zinc.

2.3 Water quality

Collins Creek on the southern extent of the proposal is a highly modified natural watercourse and has been channelised throughout much of its length and the riparian vegetation on the true right (north) of the upper parts of the stream has been removed by grazing. Aquatic habitat was variable and included riffles, runs and small pools and diverse water velocities. Streambanks are reported as steep, unstable, pugged and eroding/slumping within the site.

On the northern boundary of the site is the Northern Drain which is a highly modified soft-bottomed (sand/silt) watercourse with a straight channel alignment.

As reported within the ecology assessment, the aquatic species present represent a reasonably intact freshwater fish fauna. The ecological values of the site are however very limited. The values have been adversely affected by previous land uses which have resulted in the removal of wetlands, removal of almost all of the indigenous vegetation and the degradation of aquatic habitats in streams through livestock grazing.

2.4 Overall sensitivity of the receiving environment

Based on the knowledge of the receiving environment and the extent of the Project works, that while the Project works are assessed as low risk due to soil types and flat grades it is important that the minimisation of discharges from the mining activity occurs at all times. It is also important to recognise, and account for, that due to frequent heavy rainfall at the Project location, streams in the area can experience high turbidity events, and that following these events water returns to low turbidity relatively quickly. From a water management perspective, in particular during the mining phase of the Project, the Project risk is increased due to groundwater infiltration, in particular the volumes of groundwater that are expected to be encountered. Groundwater infiltration will therefore be a key consideration and best practice erosion and sediment control measures will need to be designed, implemented and maintained with a BPO approach to ensure appropriate environmental outcomes can be achieved overall.

3. Erosion and sediment control and water management principles

This ESCP outlines the ESC and water management measures to be utilised for the Project with these based on:

- Viewing the Project in a holistic manner. The combined effects of the construction and mining activity on the receiving environment, are considered as a whole and not in isolation from each other.;
- Minimising the potential adverse effects on the receiving environment, by using measures, both structural and non-structural that meet industry best practice and GD05 Guideline;
- Having regular 'toolbox' meetings onsite with relevant personnel in attendance as part of the ongoing mining activity;
- Ensuring that any water and associated sediment discharges are considered and assessed as part of the Project implementation;
- Ensuring that all ESC and water management measures utilised are structurally sound and designed appropriately; and
- The implementation of an adaptive monitoring programme, to inform the effectiveness of the ESC and water management measures on site and to adapt and amend these as necessary to minimise the discharge of sediment (and other contaminants) into the receiving environment. This adaptive approach is particularly applicable to the mining phase of the works.

The Project will adopt a set of key principles that apply to all work activities. Appendix B of this ESCP contains the erosion and sediment control principles as reflected within the GD05 Guideline with the specific Project principles outlined in Section 3.1 below.

3.1 ESC principles

1. ESC measures will be based on a range of structural (physical measures) and non-structural (methodologies and construction sequencing) measures.
2. ESC measures will, where practicable, meet the minimum criteria as detailed in this ESCP and will incorporate innovative ideas and procedures to ensure best practice applies and to match any local challenges and opportunities.

3. Progressive and rapid stabilisation of disturbed areas (including using mulch) will be on-going during the mining activity. Any stabilisation alternatives (not outlined within GD05 Guideline) will first be verified as an appropriate and WCRC authorised stabilisation media.

4. Stabilisation will need to be appropriate to the soil surface geology with the intent of achieving an 80% vegetative cover or non-erodible surface over the exposed area. Stabilisation is designed for both erosion control and dust minimisation and will be progressively implemented.

5. A monitoring and management approach which allows a response to water quality (turbidity and other contaminants) monitoring outcomes will be utilised for the mining activity through qualitative monitoring (which will include visual surveys and recording of any discharges and the downstream environment) and quantitative monitoring (which will include water quality sample collection and analysis).

4. Overview of erosion and sediment control and design criteria

4.1 General overview

As outlined above, for this Project we have adopted a BPO approach which reflects the current state of knowledge (as per the GD05 Guideline), the specific physical conditions to be encountered on the site and the previous knowledge of the Project team (from other similar projects) which will be reflected in the measures adopted.

Attached to this ESCP in Appendix C are plans of the proposed erosion and sediment control and water management measures that supports the Project.

In terms of general water management measures the following applies:

Construction Phase Activities

1. There will be land disturbance activities associated with bund establishment, access provisions and ancillary works. These activities are also to be addressed in full through the SSESCP process and are subject to the principles and practices as outlined within this ESCP. Appendix A of this ESCP confirms the activity, location, duration, area and volume of this work. A maximum of 8.0ha of land will be exposed at any one time through the construction and operation of the Project.

Mining Phase Activities

2. The Processing Plant may require an initial water take from Canoe Creek which will be located adjacent to the existing farm access track near the coast (or via a direct surface water take) to fill up the Processing Plant circuit including the fire water tank. A water take may be required sporadically during mining to top up the water circuit.

3. The Processing Plant water will be recovered mechanically from the HMC product and un-mineralised sands via a series of cyclones and recirculated for reuse. Some of the process water will be retained in the HMC and some will be pumped back to the pit cavity with the unmineralized sand slurry.

4. Stormwater generated in the Processing Plant area will be captured and directed to settling ponds via pumping to the treatment ponds (referred to as Ponds 1 and 2) before treated water discharges to the central drain which will convey discharged water from the mine water facility to finishing ponds (Ponds 3 and 4) in the north-western corner of the property.

5. Water from the mining void and stormwater runoff from the process plant area will be diverted or pumped to Pond 1 and Pond 2. Pond 1 includes two separate forebay impoundments which are designed to capture most of the sediment prior to flow into the main body of Pond 1 and then over a level spreader to Pond 2. Where sediment laden water will enter the Pond 1 forebay a flocculant will be added to the water to assist with sediment settlement. Appendix D confirms the soil settling tests undertaken with various flocculants, all of which demonstrate the benefits of chemical treatment. While Polyaluminium Chloride provided excellent flocculation outcomes, the specific flocculant to be used on site however will be determined prior to works commencing.

6. Maintenance of the Pond 1 forebays will be ongoing to ensure capacity remains as best practicable at all times. While 1 forebay is subject to maintenance the other forebay will be utilised. If required, the main body of Pond 1 will also be subject to maintenance clean outs. Pond 2 can also be subject to maintenance clean outs however this is not expected or will be infrequent.

7. The clean water from Pond 2 will then discharge via a pump to the central drain or be used in the process plant. The central drain has a series of rock check dams installed and these will assist with flow reduction and also will capture some sediment over time.

8. The central drain will flow to a finishing pond and the clean water facility (referred to as Ponds 3 and 4) in the southwestern corner of the property. Excess water from Pond 3 will overflow (or be pumped) into the clean water facility (Pond 4) before discharging to the environment.

9. Excess water from this finishing pond will be directed to infiltration trenches in the first instance to recharge groundwater and avoid surface water depletion. Whatever water that cannot be directed to infiltration trenches will be discharged from the finishing pond into the drain which discharges to Canoe Creek Lagoon if water quality and clarity allows.

10. If the mining phase water quality or clarity parameters as specified within the consent conditions are not met, the discharge water will be managed, in order of preference as below. In addition, as per the reporting of Mr Tom Lawson, a Clarifier with associated flocculation can also be implemented to treat all mine water discharges to the necessary mining phase water quality or clarity standards:

    i. The water will be recirculated into the processing plant and mine water facility if there is capacity in the system;

    ii. Excess water will be pumped to the Canoe Creek infiltration basin. In extreme circumstances (i.e. a 1 in 10 year flood event), water that does not infiltrate through the basin will be discharged to a swale, which discharges to the floodplain of Canoe Creek at the river mouth;

iii. Recharge barrier wells may also be employed as a fallback option to maintain groundwater levels; and

iv. As a last resort, or in extreme weather events, processing can cease and the mine pit can be flooded to provide significant additional containment and settling capacity and allow groundwater levels and stream flows to recover. This would provide time to resolve issues before recommencing discharge.

Further to this as detailed above a “back up” filtration system will be made available on site and can be commissioned as required to assist with achievement of the water quality parameters.

<u>Overall Earthworks</u>

11. The Project has committed to having a maximum area open at any one time of 8.0ha. This includes all the bund establishment and road access provisions. This has the effect of ensuring, including through site establishment phases, that progressive stabilisation is implemented and the risk of sediment generation and discharges are greatly reduced.

The overview water management process for both the construction and mining phases are illustrated below in Figure 5. As detailed above a “back up” water filtration will also be available. This filtration system will be purchased and positioned on site from mining commencement to ensure that if such a system is demonstrated to be required then commissioning can occur within a very short timeframe.

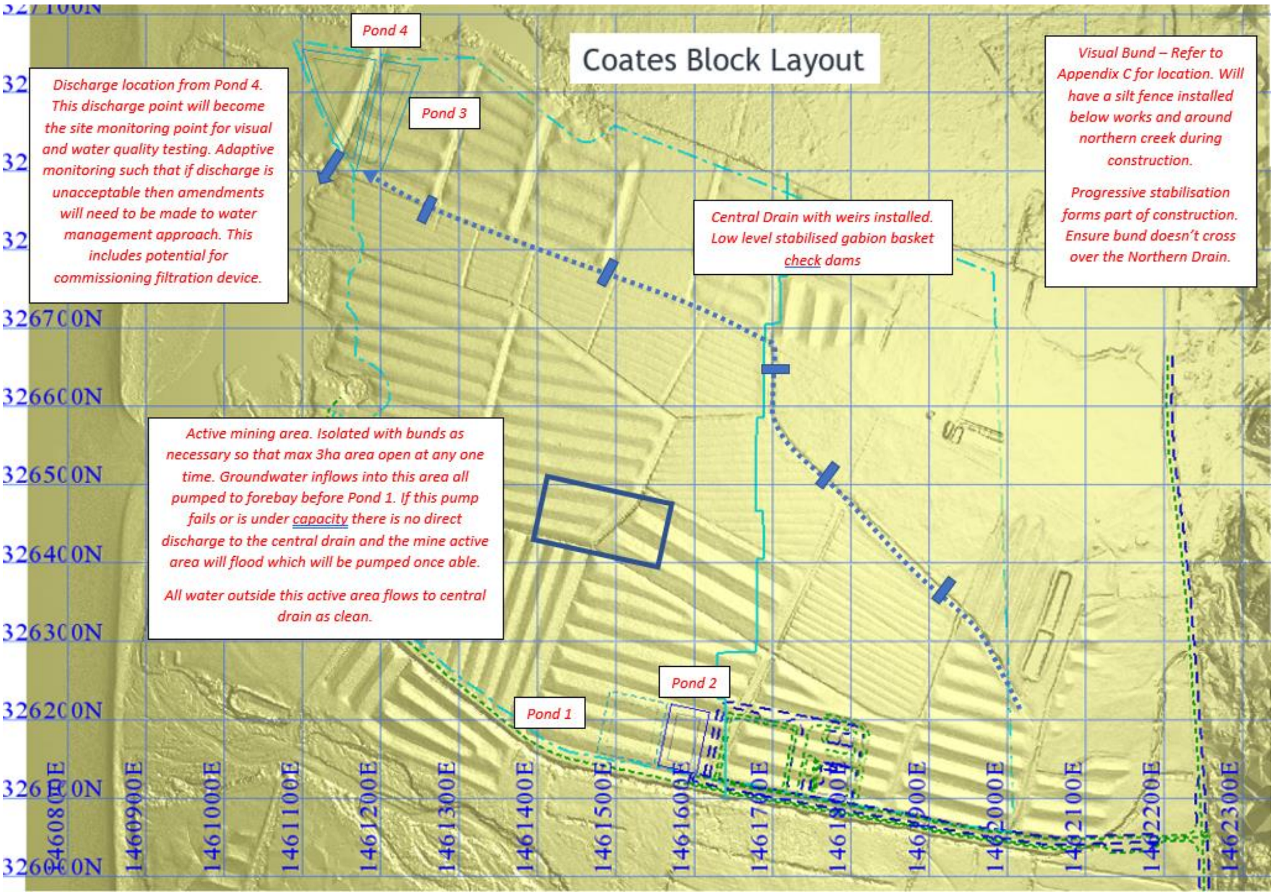


Figure Five: General Water Flow and Treatment Facility Locations

For the mining phase, mining will progress in strips, with a dimension of 100m wide (strip width) and 300m long. The mine pit area will be 3ha, including 0.5ha of stripping occurring ahead of the mine pit and 0.5ha of active rehabilitation occurring behind the mine pit. Mining will commence in the southwest of the area (Panel 1 as per Appendix A), and progressively moves eastwards on 100 wide strips/panels. Each subsequent strip of mining is located north of the previous strip, with the exception of Panel 9, which is located in the southwestern most extent of mining. Mining along each strip is always from the west to the east.

20m mining setbacks will apply to the northern and southern property boundaries, Collins Creek and the coastal lagoon area. The area south and west of Collins Creek is also excluded from the mining area.

This mining process is illustrated below in Figure 6.

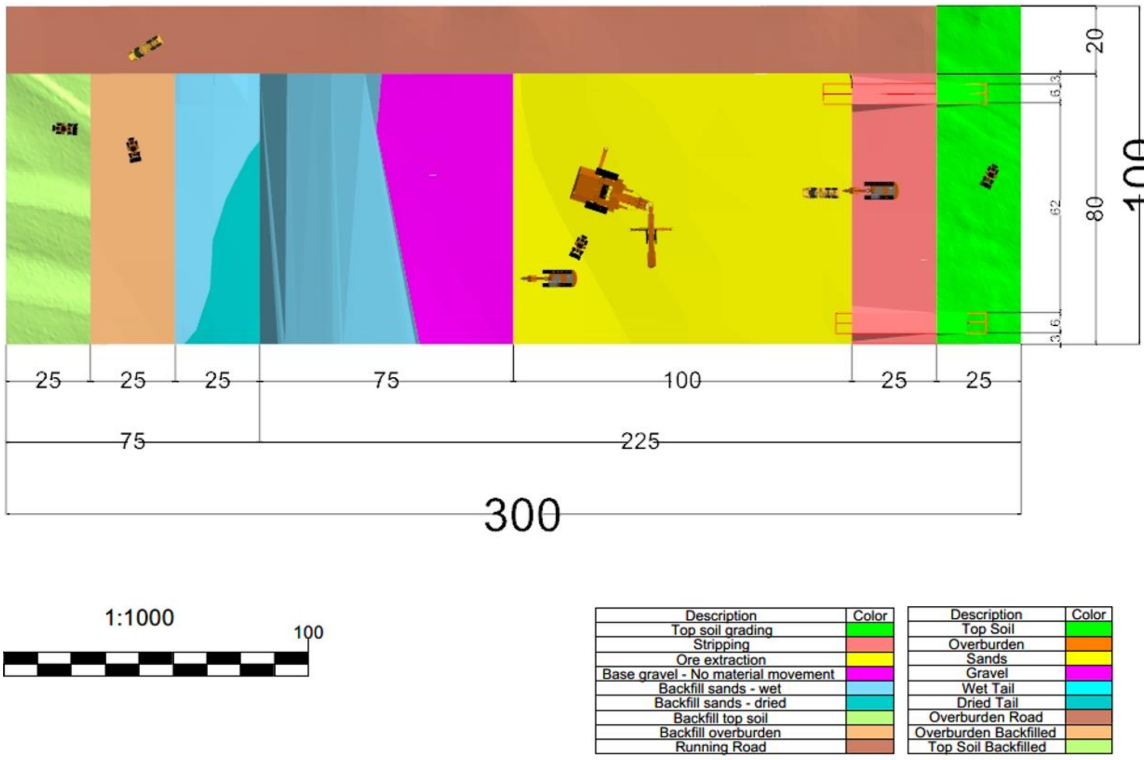


Figure Six: Mining Sequence

Final rehabilitation of the Project will include returning the land back to agricultural land use. This is to all occur within the mining disturbance area and will have the following general sequence.

1. As per Figure 6 above as the mine progresses there will be ongoing rehabilitation with the land returned to final landform and a stabilised surface. There may be some final shaping at the end of the Project life to ensure the contours "marry into"" the surrounding landform.

2. Any areas outside the mining process (as per Figure 6 above) that are not subject to progressive rehabilitation will be subject to rehabilitation as a separate activity. This will be humped and hollowed to be consistent with the progressive rehabilitation area. This may include some borrow material for the final panel progressive rehabilitation and to ensure the western extent of the Project maintains its original height above sea level in its final form.

The Rehabilitation Management Plan confirms:

"The post mining contour is created from redistribution of some material located between the Mining cut off and the edge of the mine disturbance area. This area is approximately 20 hectares which be recontoured as shown in Figure 10 to match in with the landform created as part of the progressive rehab. This area will also hold the pre-stripped ore, overburden and topsoil extracted as part of the pre-mining activities and development of mine infrastructure."

This rehabilitation outside of the mining sequence will remain subject to the SSESCP process and it is expected this will be managed through the provision of topsoil bunding, working within the open area restrictions and progressive stabilisation.

4.2 Key erosion control measures

In general, the erosion control measures to be applied to the Project are as below.

4.2.1 Construction staging and stabilisation

As a general approach to all land disturbance, but with specific reference to the construction phase and the rehabilitation of the mine pit, the Project will minimise soil exposure and undertake progressive rehabilitation and stabilisation as areas of the mine are completed. As detailed above an ongoing 0.5ha of rehabilitation will be ongoing at all times following the mine advancement.

Stabilised is defined as:

> *An area inherently resistant to erosion such as rock, or rendered resistant by the application of aggregate, geotextile, vegetation, mulch or an approved alternative. Where vegetation is to be used on a surface that is not otherwise resistant to erosion, the surface is considered stabilised once an 80% vegetation cover has been established.*

Typical revegetation will include seeding and fertiliser application on topsoiled areas and hydroseeding, however where instant stabilisation is required, hay and/or straw mulch may be utilised.

In addition to the mine rehabilitation process, the visual bund to be established along SH6 (see Appendix A) will also be planted as detailed within the Landscape Assessment Report.

Importantly, utilising traditional grass sowing methodologies is not considered stabilised until such a time as 80% vegetative cover is established on site however the use of hay or straw mulch and as well as hardfill with clean aggregate is confirmed as immediately creating a stabilised surface. If alternatives, such as polymer/soil binder products or hydroseeding are to be utilised they will need to be verified by WCRC as achieving a stabilised surface prior to on site use.

The use of stabilisation is designed with 2 key purposes being dust suppression and also erosion control.

4.2.2 Rock check dams

Check dams are small dams made of rock rip-rap or other non-erodible material constructed across a swale or channel to act as grade-control structures. Their purpose is to reduce the velocity of concentrated flows and they are often placed in series down a channel and used to reduce invert scour in drains or channels.

Rock check dams in the form of gabion baskets will be utilised on the Project within the central drain to assist with slowing velocity of any flows, ensure scour and erosion of this drain is minimised and also will perform a secondary function of collecting and trapping any sediment that may remain in flows at that point. In addition, consideration will be given to constructing these from limestone rock for the purpose of increasing water hardness to avoid potential toxicity of any naturally present metals[1] in water pumped from the mining void.

4.2.3 Stabilised construction entranceway

Stabilised construction entranceways are a stabilised pad of aggregate placed on a filter base and are located where construction traffic will exit or enter a construction site. They help to prevent site entry and exit points from becoming a source of sediment and also help to reduce dust generation and disturbance along public roads. On this Project stabilised entrances will be utilised with SH6. GD05 Guideline will assist with the provision of the design criteria.

No vehicles will be allowed to leave the Project site unless tyres are clean and vehicles will not contribute to sediment deposition on public road surfaces. The processing plant location and associated access roads will all be aggregate stabilised and as such will in themselves act as stabilised entrance ways.

4.3 Key sediment control measures

Sediment control on the Project will involve the treatment of sediment-laden runoff from construction phase activities and also mine process water from the various areas of the Project but in particular the active mining area. Sediment control will be established through the use of recognised sediment control measures and site management practices.

The sediment control measures to be applied to the Project are as follows:

4.3.1 Sediment impoundment locations

Treatment of surface runoff and sediment contaminated groundwater infiltration from the mining area will occur to ensure that sediment is removed to the maximum extent possible from the construction runoff before being discharged to the receiving environment. Sediment Retention Ponds (SRPs) provide the most robust and effective measure in achieving sediment removal from construction runoff.

It is assessed for this Project that while the GD05 Guideline reflects the most up to date and best practice SRP design criteria, that due to the infiltration of groundwater within the mining area

[1] Addressed in the evidence of Dr Mike Fitzpatrick

itself, that a large volume impoundment will provide the best approach and will be utilised. This impoundment has a volume significantly larger than that from within GD05 Guideline design criteria and will capture surface runoff from the 3.0ha maximum open area of the mining pit and also up to 68 L/sec of infiltration of groundwater.

Two formal forebays will be established at Pond 1 with the discharge from these forebays to occur over a level spreader to the main body of Pond 1. Pond 1 will then discharge into Pond 2 via a level spreader (or pumping) to Pond 2 which will also provide a polishing of runoff prior to discharge to the Central Drain.

The general water management discharge sequence is as follows:

1. Active mining area and associated activities including the processing plant.

2. This area (and groundwater infiltration) will discharge via pumping to Pond 1 which has a capacity of 32,500m^3. This pond has adequate capacity for the full capture of a 20 year 24hr rain event in addition to groundwater infiltration with remaining capacity for a further 24 hour period of the same conditions. In addition, this pond is expected to have some natural groundwater infiltration and as such a longer capacity duration is expected.

3. Pond 1 will have two forebays (each having a capacity of 3,200m^3) which will assist with maintenance and also flocculation. While Polyaluminium Chloride provided excellent flocculation outcomes, the specific flocculant to be used on site however will be determined prior to works commencing.

4. Clean water diversions (CWD) will be installed around the mining void and also other earthwork areas as and when necessary to ensure only the active area can discharge to Pond 1 or the designation sediment control measure. While the specific sizing of the CWD will be detailed within the SSESCP, Appendix E of this ESCP provides an example of a CWD design that may apply to the Project.

5. Pond 1 will flow via a level spreader or pumping to Pond 2 which has a capacity of 20,300m^3.

6. Pond 1 and 2 (particularly the forebays of Pond 1) will need to be maintained on a regular basis.

7. Pond 2 will be used as process water or discharge via pump to the Central Drain. This Central Drain already exists but weirs will be installed within it to assist with any further sedimentation that remains in the flows. These weirs are designed as check dams and they will be removed over time.

8. This Central Drain will flow into Pond 3 which has a total volume of 28,100m^3. This will act as a further coarse sediment trap and this in turn discharges to Pond 4 with a capacity of 36,800m^3 via a level spreader.

9. The Central Drain will require some amendments over time as the mine void progresses to allow mining in those locations where the Central Drain currently exists. This has been observed on site and will be the subject of a SSESCP however it is likely that the Central Drain will be diverted south through the completed Panel 3 once the Panel 3 mine void is fully rehabilitated.

10. Pond 4 will discharge in order of priority as follows:

- pump to the infiltration trenches on the northern and western boundaries for groundwater recharge;
- if groundwater recharge is not necessary pump to surface water which could include the coastal lagoon avoiding direct discharges to the coastal environment. This can only occur if water quality criteria is achieved;
- if water quality criteria can not be achieved then pump to infiltration pit adjacent to Canoe Creek; and
- as a final option if the other alternatives are not feasible , at capacity or criteria can not be achieved, then the mine operation can cease, pumping can also cease and the mine void will be flooded. This will provide time and the ability to reconsider other options.

The process and operating procedures to ensure that the above sequence occurs and achieves the environmental outcomes is provided within Mr Rekker and Mr Lawson's assessment. In addition, as noted above Mr Lawson has confirmed an alternative treatment approach whereby a clarifier system incorporating flocculation is implemented for all discharges from the mining void with this confirming a further back up if necessary to achieve the necessary water quality and/or clarity parameters.

For the specific construction of the impoundment locations, in particular Ponds 1 and 2, bunding will occur between the earthworks activity and the Collins Creek such that there is no direct discharge to this environment. The excavation itself will also form an impoundment for water collection which in turn can be discharged via the Central Drain to Ponds 3 and 4. A small filtration device (such as a lamella plant) can also be utilised if required to achieve water quality parameters.

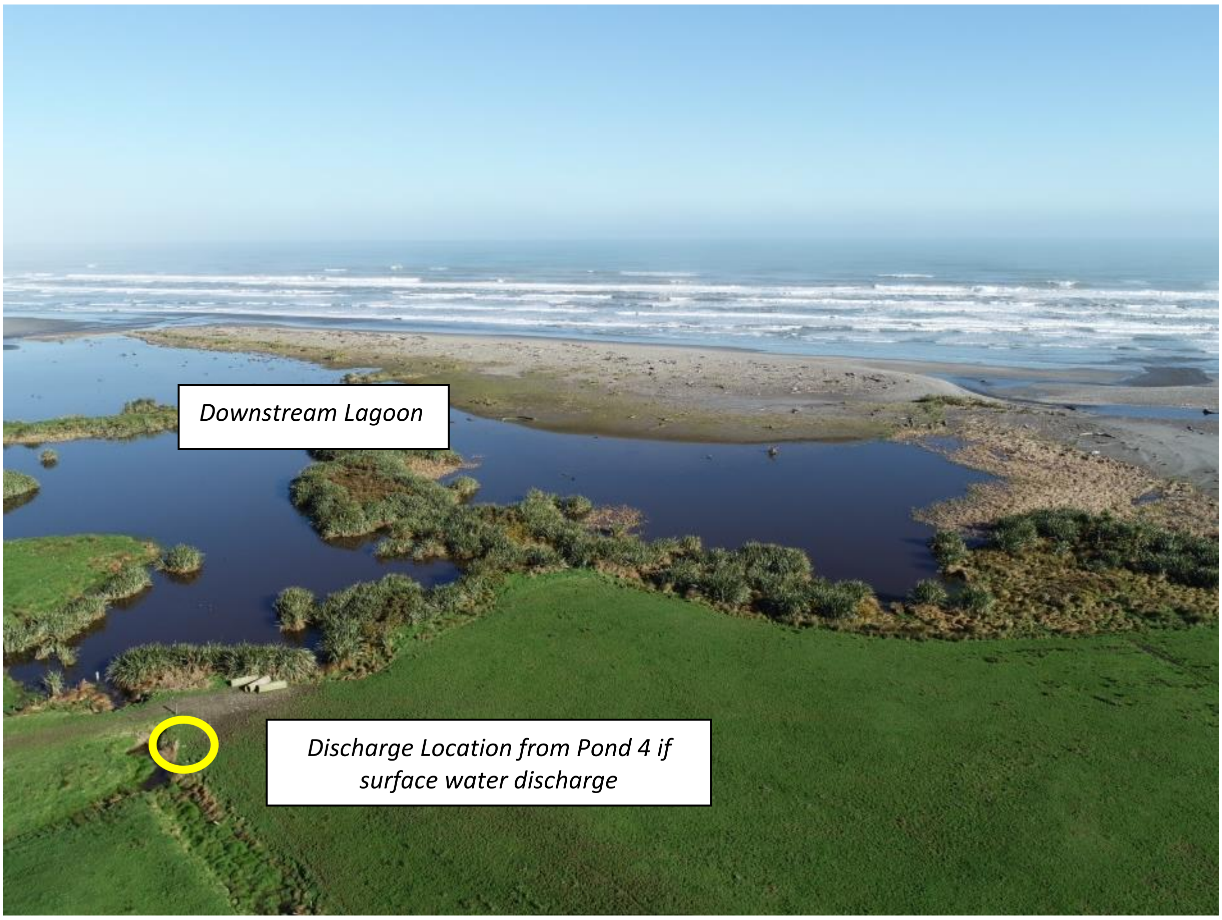


Figure Seven: Discharge Location

This above process is illustrated in Figure 5 above and further in Figure 8 below for Ponds 1 and 2.

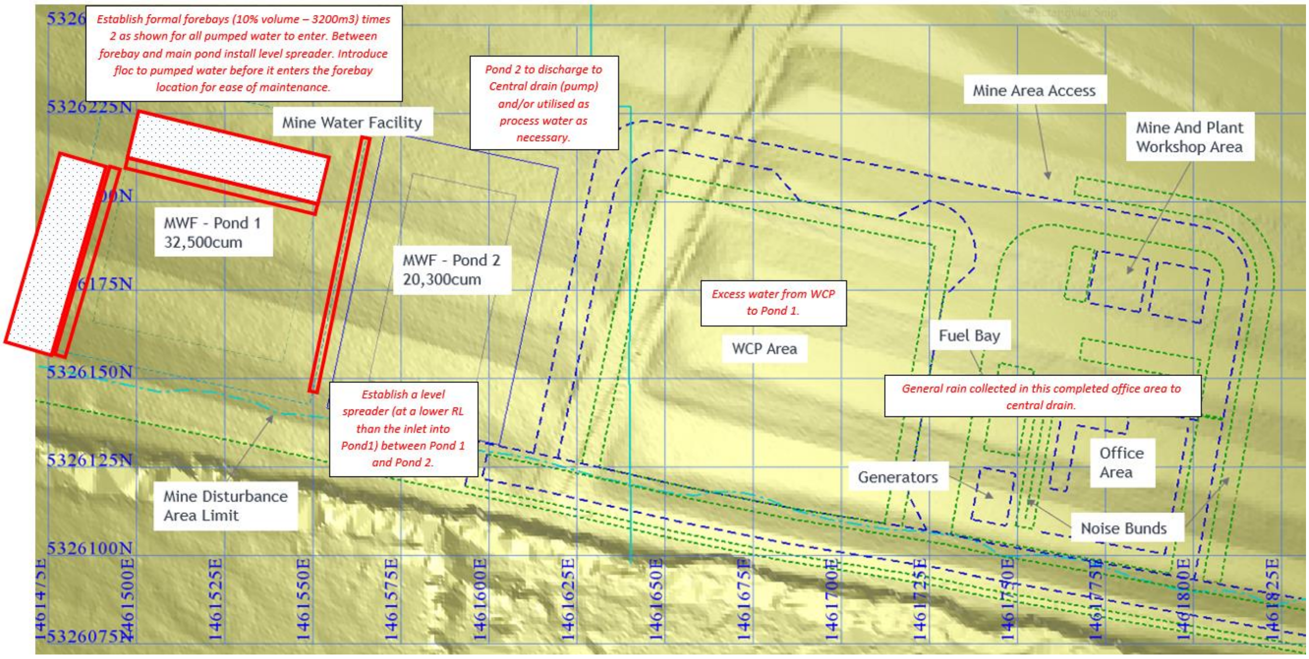


Figure Eight: Ponds 1 and 2 Details

4.3.2 Chemical treatment

Attached in Appendix D is a report outlining the results of chemical treatment of the soils and associated runoff that will eventuate from these. This report confirms the benefits of flocculation and for this Project the specific chemical used, dose rates and the design will all be confirmed prior to works commencing. This will be detailed within the SSESCP to be submitted and updated and verified further through the AWP.

4.3.3 Dirty water diversions (DWD)

DWDs transfer sediment laden water to treatment devices. They are effectively a conveyance device and are designed to cater for the 20-year ARI rain event with a 1-hour duration (plus a 300mm freeboard). Due to the nature of the mining sequence, it is unlikely that DWD will be required for the Project as all dirty water will be pumped to Pond 1 forebays. If required however, the DWD design criteria for the Project will ensure that all construction runoff from the active mining location (including any areas not yet stabilised) from rain events up to the 20-year ARI event will be transferred to Pond 1. This design (including the freeboard provision) effectively has the same capacity as a 100-year rainfall event and therefore is assessed as providing a robust and best practice approach.

A maintenance programme will be implemented during Project construction activity to remove any resultant sediment deposited within the DWD. The DWD will also have drop out pits with a $2m^3$ volume capacity established at 50m intervals along the channel itself to assist with the capture of the heavier particle size sediments that are generated.

These DWD will be moved on an ongoing basis as the mine area also moves to ensure that there is always flow from this active area to Pond 1.

4.3.4 Silt fence (SF) and Super silt fence (SSF)

SF and SSF are fabric fences reinforced with waratahs / stakes and a chain-link backing (SSF only) to allow a physical barrier to sediment laden flows leaving the area of earthworks. This barrier acts as a detention and filter for these flows to ensure sediment yield is minimised. Their design and placement will be based upon the criteria contained within the GD05 Guideline.

SFs will be utilised during the construction phase as part of the visual bund establishment along SH6 and access road establishment. The SF will be returned up the Northern Drain in order to protect this from any earthworks and sediment runoff. These SFs will be complemented with progressive stabilisation.

In addition, for the central bund and pre-mining ore stockpile location this will be protected with SFs as shown within Appendix C. These stockpiles and bunds will be placed progressively, will avoid direct placement over the Central Drain and will be stabilised as they progress. Adjacent to the Central Drain itself SSF will be utilised to provide more robust control measures.

The GD05 Guideline notes that design criteria as below which will be adopted.

Table 13: Silt fence design criteria

Slope steepness %	Slope length (m) (maximum)	Spacing of returns (m)	Silt fence length (m) (maximum)
Flatter than 2%	Unlimited	N/A	Unlimited
2 – 10%	40	60	300
10 – 20%	30	50	230
20 – 33%	20	40	150
33 – 50%	15	30	75
> 50%	6	20	40

Table One: GWRC 2021 Guideline Table 13 Silt Fence Criteria

4.4 Decommissioning of devices

All ESC measures will remain in place until such a time as the construction activity or mining operation has ceased or the circumstance where the catchment contributing to that device is stabilised. Once the contributing catchment is considered stabilised, or other measures are in place as agreed with WCRC, the measure will be decommissioned in consultation with WCRC.

For the mining activity itself, as described above the ESC measures will remain for the full operation and duration of Project.

4.5 Pumping

Pumping will be necessary in some parts of the Project. Pump intakes will be fitted with floating intakes and all pumping will only be to impoundment areas or the infiltration device. There will be no pumping of any on site water directly to the receiving environment.

The contractor may also wish to initiate a permit to pump system whereby pumping can only occur with a specific "internal" permit in place which confirms all the necessary criteria, including water quality, have been achieved prior to the pumping itself.

4.6 Stream crossing

Collins Creek is to be crossed with an access road as shown in Appendix A and Figure 9 below. This will include installation of a culvert or equivalent design which is understood to be a permitted activity however the construction methodology is addressed as below.

The works will be undertaken in a dry environment. This will be achieved by undertaking culvert installation offline prior to diversion of flows or pumping flows around the area of works will occur. No formal channel diversions are expected to be required as part of the culvert establishment.

Prior to works commencing specific culvert sizing will be confirmed, based on upstream catchment area and characteristics, timing of works and the expected duration of works.

The general approach to achieving a dry environment for the culvert installation is as follows:

- A pump will be installed approximately 5m upstream of the works extent of an upstream temporary bund. This pump will pump upstream flows around the work area to discharge back downstream of the culvert works. Sand bags or similar will be used to impound flows for this pump. The inlet of the pump will be supported above the base of the impoundment area to minimise sediment input. It is important to note that the capacity of the pump will be determined to manage the low flows during works.

- The initial excavation will remove any vegetation or other material from the work area followed by the excavation of unsuitable material. This excavated material will be disposed of elsewhere on the Project site within the catchment of other erosion and sediment controls.

- Once all unsuitable material has been removed, the crossing area will be backfilled with bedding material to an appropriate depth for culvert installation. The culvert will be installed with associated wingwalls, retaining walls and backfill as necessary. Rock rip-rap erosion control will also be installed at the inlet and outlet of the culvert.

- The associated activity over the crossing will occur (filling etc) with other erosion and sediment controls in place which typically includes the installation of a super silt fence. When the works have been completed any disturbed area will be fully stabilised with either hardfill or mulch.

- The culvert will be installed in accordance with Regulation 70 of the National Environmental Standard for Freshwater Management 2020, including providing unimpeded fish passage.

For all culvert works:

- Prior to any works commencing with the installation, a suitable weather window will be confirmed (3-day fine weather window recommended) and any concerns or further clarification at the time, will be addressed immediately and prior to any works commencing on site.

- Any water within the works area that results from the pipe installation will be pumped to and approved location or sucker truck for removal from the site.

- In the event of high rainfall during the course of crossing installation, or prior to leaving the site for more than a 24 hour period, the Project team will ensure the following:

  - Any loose material that could enter a stream system is to be removed;

  - Any downstream sand bag barriers will be checked and, if required removed for heavy rainfall and stream flow events; and

  - All existing and additional sediment control measures will be inspected and secured and maintained where required should a significant rainfall event be imminent.

The key construction water management process is ensuring that at the end of every day, and in particular prior to rain events, that a fully stabilised work site remains that can effectively continue to operate as required with minimal scour and contaminated discharge.

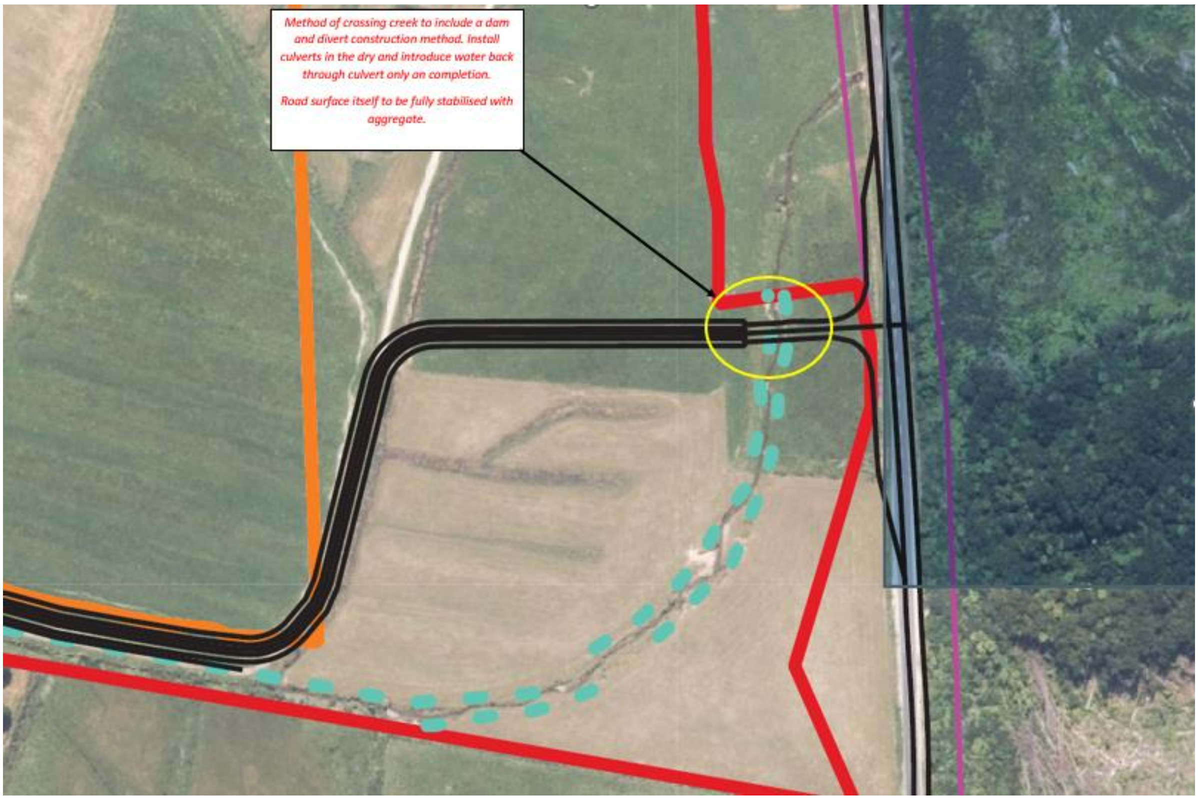


Figure Nine: Collins Creek Crossing – Approximate Location

5. Monitoring

An adaptive monitoring programme will be implemented for the Project. This monitoring programme will involve ongoing site monitoring to check that the ESC water management measures have been installed correctly and that methodologies are being followed and are functioning effectively throughout the duration of the works. This will also directly inform the AWP for the Project.

Monitoring results that eventuate, as defined below, will also be used to identify future risks to the environment and will identify any continuous improvement opportunities that should be considered by the construction team.

Water management measures and methodologies may be identified as requiring modification or improvement, including those causing raised levels of sedimentation.

The monitoring programme will include risk assessment to determine what further measures are required to reduce construction discharges. The adaptive monitoring will include a continual feedback loop until it has been verified that the implemented responses have been successful in minimising discharges from the Project construction.

5.1 Qualitative monitoring

5.1.1 On-site visual assessments

Visual assessments of the receiving environment will be undertaken regularly throughout the works period with particular attention paid before, during and after periods of rainfall.

In the context of visual assessment, the receiving environment is defined as the infiltration trench and any discharges to surface water including the downstream coastal lagoon.

This monitoring will include visual observations of all pond outlets, all pump discharge locations, the central drain and the receiving environment. This will occur a minimum of once per day and also after rainfall with a record kept of these inspections.

Any noticeable change in water clarity from the water clarity prior to the rainfall event, or the water clarity upstream of the site of works, as a result of the earthworks activity will result in a review of the water management measures and practices and additional measures will be implemented, and changes made as necessary under the adaptive management process.

In addition, inspections of the devices themselves will include qualitative monitoring of the following:

- The integrity and effectiveness of all construction related water management devices with a focus on the treatment ponds and requirement for maintenance;

- Construction and mining activities onsite;
- General site conditions and other land disturbing activities occurring within the catchment; and
- General status of the immediate receiving environment.

To ensure a full understanding of the area of works is available, prior to construction commencing, photographs will be taken in the vicinity of proposed discharge outlet points and any streams in the vicinity of the works.

These records will illustrate the visual state of the receiving environment at and within the vicinity of the discharge point. This photographic record will allow a visual comparison of before, during and at completion of the Project.

The monitoring data will help to determine whether any further action is necessary. Where issues with the integrity and/or effectiveness of the devices and/or methodologies are observed these will be rectified immediately.

5.1.2 Weather forecasting during Project implementation

Weather forecast monitoring will form an important part of the Project implementation to ensure that these higher risk periods are proactively managed appropriately.

We note the extensive use of weather forecasting that now occurs with most land-disturbing activities and the value that it provides in informing projects of upcoming weather systems. Metvuw is assessed as an appropriate tool in this regard and within this tool, utilisation of a red rainfall warning will allow for proactive pre rain inspections to occur. This is a qualitative assessment as above and is to ensure that all measures are fully functional prior to the rain event.

5.2 Quantitative monitoring

As part of the mining phase for the Project, and as documented within the proposed conditions of consent, quantitative sampling for sediment discharge will occur and will include:

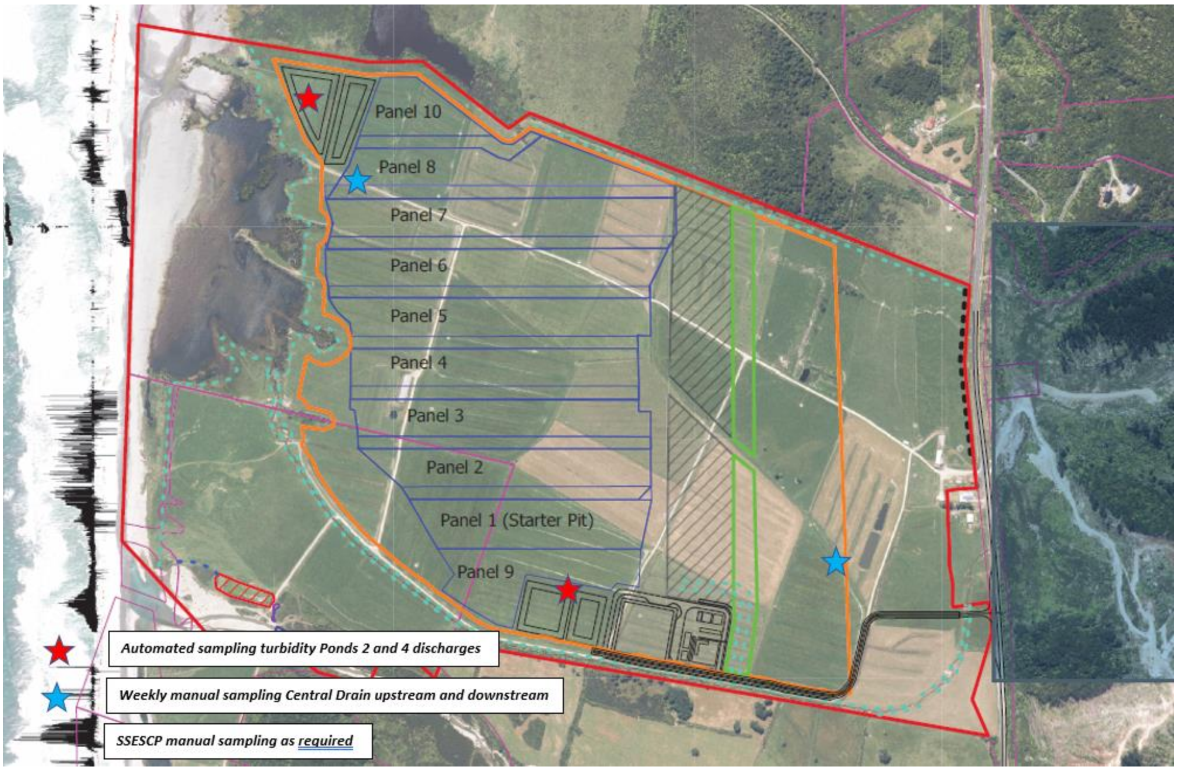
- Automated continuous sampling for turbidity at the discharge from Pond 2;
- Automated continuous sampling for turbidity at the discharge from Pond 4;
- Manual sampling for turbidity using field meters or grab samples on a weekly basis within the Central Drain upstream of the mining activity;
- Manual sampling for turbidity using field meters on a weekly basis within the Central Drain immediately prior to Pond 3; and

- Other manual grab water quality sampling of turbidity and total suspended solids on a SSESCP basis dependent upon the activity and the discharge location. This shall include upstream and downstream sampling of discharges during the construction activities.

While no specific discharge water quality standards are recommended within this ESCP for the short-term construction activities it is assessed that reliance on the details within this ESCP and the future SSESCP process remains as the best practice and effective approach. Utilisation of field turbidity meters during this construction phase can also be implemented to assist with understanding of any water quality changes over that short period.

For the mining phase activities and associated discharges, specific water quality and clarity standards are proposed within the consent conditions and are assessed by others.

A plan of proposed sampling locations is included below.



6. Recommendations and conclusions

The following key points are noted for the Project.

- Due to the controlled nature of the mining phase works and the staged approach and progressive stabilisation of rehabilitated areas, the risk of erosion and consequential sediment discharges is low.

- All other land disturbance activities (construction phase) are short term and will be managed with ESC measures that are compliant with GD05 Guideline.

- The highest risk of sediment discharge is a result of the groundwater infiltration that may result. This infiltration rate will be variable and will be managed appropriately through the proposed water management systems.

- A range of ESC and water management measures are proposed on the Project that meet the GD05 Guideline criteria or provide an alternative best practice measure. ESCs will be based on both structural and non-structural measures with an emphasis placed on the non-structural management techniques.

- An adaptive monitoring programme will be implemented which will allow for ongoing continuous improvement of the ESC and water management measures and will allow for annual reporting and adaptations all detailed within the AWP. The monitoring regime includes construction phase qualitative monitoring and also specific quantitative monitoring for the mining phase of the Project.

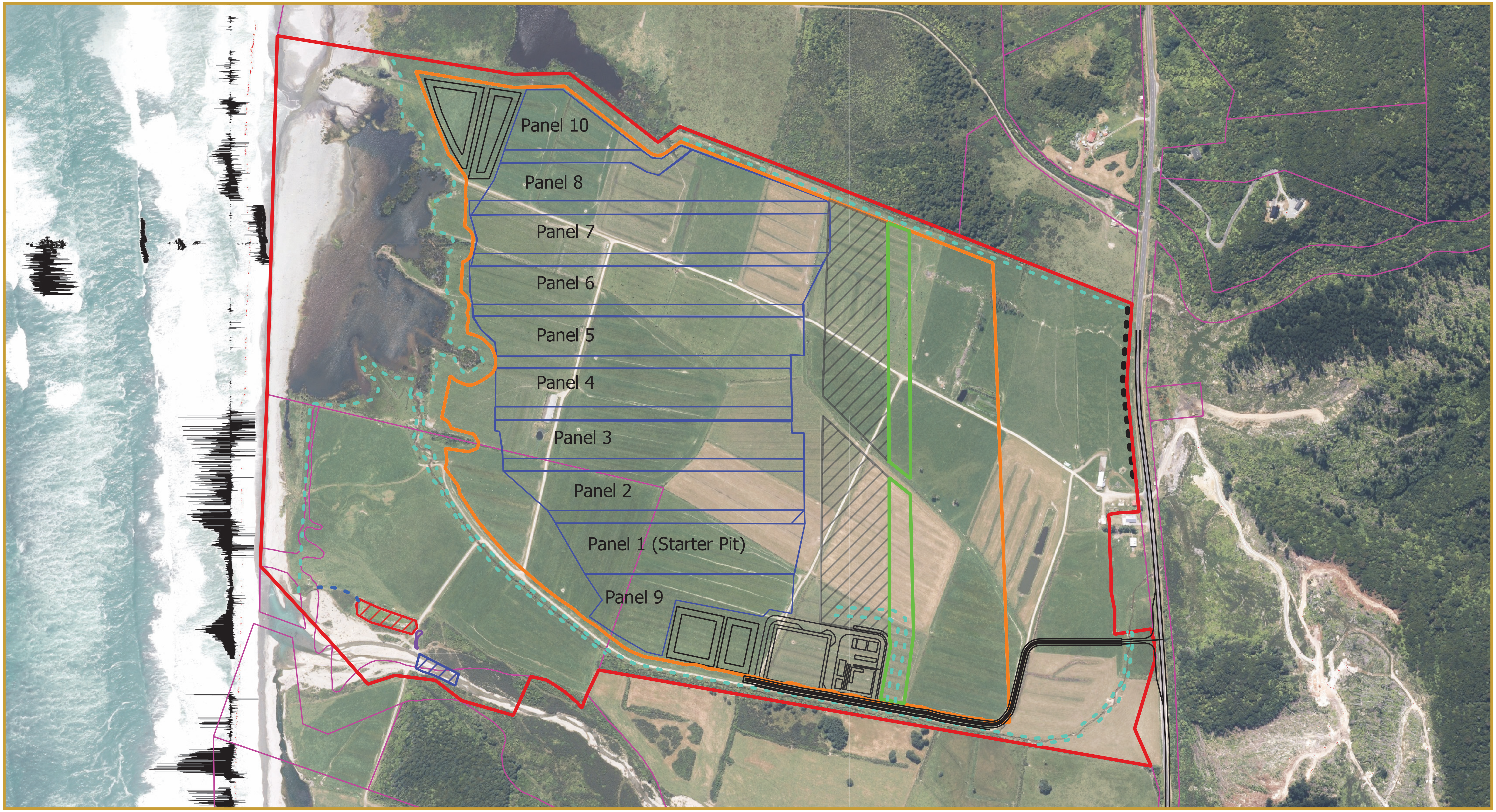
7. References

Auckland Regional Council (1994). Storm Sediment Yields from Basins with Various Land-uses in Auckland Area.

Auckland Council 2020. Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland region. June 2016 incorporating Amendment 2.

Goldman, Steven J, Jackson, Katharine, Bursztynsky, Taras A. Erosion and Sediment Control Handbook. (1986)

Appendix A. Overview Project Site Plan and Construction Sequence



Tai Poutini RESOURCES

TiGa Consent Application
Amended Map

Legend:

- Planting
- TiGa Application Area 21022023
- Bund
- Gallery Water Take
- Watertake Location
- Premining ore stockpile
- Mining Disturbance Area
- Mine Infrastructure
- Overflow Channel
- Water Infiltration Area
- Mining Strips
- Bund and Planting
- Property Boundaries

Note: Refer to Landscape Mitigation Plan for detailed Information on Bunds and Planting.

Produced for: TiGa
by Luke McNeish on 12/06/2023

0 125 250 375 m

1:8,000 @ A3

Projection: WSG84 / NZTM2000
Background Imagery: ESRI Satellite
Data Sources: LINZ, Client and or TPRL Data

Construction Sequence and Earthwork Details - Estimates Only

Sequence	Activity	Phase of Works	Machinery	Location	Estimated Duration of Works	Area of Disturbance	Volume of Disturbance	Discharge Location	EC Measures to be Utilised
1	Eastern Limit Bunds	Construction	Excavator	North of Central Drain Alongside State Highway with a gap in the bund to allow culvert outfall to remain to Northern Drain	24 days	2.52 ha	63,800 m3	Northern Drain	Silt Fence around Northern Drain and stabilise immediately on completion. Can bund and pump if required.
2	Central Drain	Construction	Excavator	Central Drain	7 days	0.5 ha	0 m3	Discharge into the Lagoon and Northern Drain until the CWF established	Gabions installed within channel. Monitor and erosion protection if required. Once we get to Panel 3 (or earlier if required) establish a new drain and this will have vegetation and protection established as necessary. This will involve a dam and divert and stabilise as necessary with details in SSESCP
3	Clean Water Facility (CWF) and Central Bund	Construction	Excavator & Trucks	North Western Corner	14 days	1.4 ha	Pond 3 (28,100 m3) Pond 4 (36,800 m3)	Water retained within water facility. Topsoil and waste material carted to North -End of Central Bund to provide bunding. Water run off collected and directed to Central Drain.	Progressive stabilisation. When excavating ponds utilise some of the material to form bunds around the ponds. Can utilise silt fences and impoundment if required. Central drain protected with super silt fence
4	Mine Water Facility Construction (MWF) and Central Bund	Construction	Excavator & Trucks	Near Plant Site	14 days	1.05 ha	Pond 1 (32,500 m3) Pond 2 (20,300 m3)	Water retained within water facility. Topsoil and waste material carted to South -End of Central Bund to provide bunding around the plant. Water within the area to be fed back to clean mine water facility. No discharge to Collins Creek.	Utilise Ponds built first. When excavating ponds we will need to utilise some of the material to form bunds around the ponds - the pond vol required is the live vol above the ground water level. Central drain protected with super silt fence.
5	Ore and Waste Dump	Construction	Excavator & Trucks	Commence North End of Ore Dump	28 days	5.3 Ha	Will be the destination of ore and waste material from the CWF, MWF and Pre-Mining Void	All ore from the dams will be carted to the North end of the ore dump - Central next to stockpile. Water run off from this area to be collected and then directed to Central Drain once works completed on CWF and MWF. Haul Roads included.	Existing super silt fence and progressive stabilisation
6	Plant Site	Construction	Excavator, Grader & trucks	Plant Site	28 days	1.9 ha	0 m3	Excess waste and top soil carted to south end of Central Bund. Water directed to MWF	Silt Fence and progressive stabilisation.
7	Access Road	Construction	Excavator, Grader & trucks	From State Highway	14 days	0.55 ha	0 m3	MWF and Central Drain however no discharge into the Collins from access road.	Progressive stabilisation with clean aggregate
8	Pre - Mining Void	Mining	Excavator, Grader & trucks	Panel 1	20 days	3 Ha	137,900 m3	MWF + Central Drain and CWF and if required Filtration System	MWF & CWF

Appendix B. ESC Principles

A2.0 Fundamental principles of erosion and sediment control

An awareness of where water goes and the sensitivity of the receiving environments are fundamental to determining requirements for erosion and sediment control for land disturbing activities. The following ten fundamental principles of ESC provide best-practice guidance for minimising the adverse effects of erosion and sedimentation through the planning, construction and maintenance phases of a project. These should be followed when preparing and implementing an ESC plan.

1. Minimise disturbance

Consistent with the concepts of water sensitive design (WSD – formerly referred to as low impact design) in Auckland Council guideline GD04, the identification and retention of existing site attributes should be incorporated into project designs, and earthworks should be minimised to the greatest practicable extent.

Land development should be fitted to land sensitivity and where possible, disturbance should avoid steeper slopes and other features such as streams and wetlands.

For any development, the total area of earthworks should be the minimum necessary to achieve the design outcome (including temporary works). The area of earthworks exposed to erosion at any given time should also be minimised through staging and progressive stabilisation.

2. Stage construction

Carrying out bulk earthworks over the whole site maximises the time and area that soil is exposed and prone to erosion. By only exposing those areas that are required for active earthworking at any one time, the duration of exposure and risk of erosion/sediment discharge can be minimised. ‘Earthworks staging’, where the site has earthworks undertaken in smaller units over time with progressive revegetation, limits erosion.

Careful planning is needed. Temporary stockpiles, access and utility service installation all need to be planned. Earthworks staging needs to be planned in conjunction with the overall construction sequencing to ensure that it accommodates the contractor’s requirements.

3. Protect slopes

If slopes are worked and require stabilisation, simple vegetative covers such as topsoiling and seeding may not be immediately effective and additional measures may be required. These are described in Section E3.0 of Part 2 - Practices. Disturbance of existing slopes should be avoided wherever possible, particularly steep slopes which have a higher risk of erosion. To minimise erosion, clean water runoff from above the site must be diverted away from the exposed slopes.

4. Protect receiving environments

Receiving environments including sensitive receiving environments[2], existing streams, watercourses and proposed drainage patterns need to be mapped. Earthworks and the removal of vegetation beside or within streams (including intermittent streams), wetlands and the coast, typically require consents from Auckland Council. Auckland Council should be consulted on these matters prior to finalising project designs.

All receiving environments, limits of disturbance and protection measures should be mapped on the ESC Plan. In addition, all practices to be used to protect new drainage channels should be marked, as well as crossings, disturbances and associated construction methods.

5. Rapidly stabilise exposed areas

Disturbed soils should be progressively stabilised with vegetation, mulch, grassing or other stabilising methods after each earthworks stage and at specific milestones within stages. Available stabilisation methods are site-specific and are described in Section E3.0 of Part 2 - Practices.

6. Install perimeter controls and diversions

Perimeter controls and diversion measures help separate 'clean water' from outside the area of disturbance from 'dirty water' that has flowed through the disturbed area. Minimising the earthworks catchment by diverting clean runoff away from the works area is a critical erosion control measure. It also reduces the size of sediment control devices required for any given works area. Perimeter and diversion controls can also retain or direct sediment-laden runoff within the site. Common controls are diversion drains and earth bunds. These are detailed in Section E2.0 of Part 2 – Practices.

7. Employ sediment retention devices

Even with the best ESC practices, earthworks will discharge sediment-laden runoff during and immediately following storms. Along with erosion control measures, sediment retention devices are needed to capture runoff so generated sediment can settle out and be retained on site. These are detailed in Section F1.0 of Part 2 – Practices.

The fine-grained nature of Auckland soils means sediment retention ponds will usually require flocculant treatment (flocculation) to maximise their efficiency. All sediment retention devices must be sized and maintained in accordance with this guideline, and must be appropriate for any given location within a site.

[2] Sensitive receiving environment are defined within Section J1 of the Auckland Unitary Plan (operative in part) as an 'area where wastewater, stormwater or other discharges have the potential to have adverse impacts on important natural or human uses or values in marine, freshwater, and terrestrial environments.' Overlays D4 – D9 within the plan identify lakes, rivers, streams and wetlands that are especially vulnerable to the adverse effects of development.

8. Get trained and develop experience

As contractors are generally responsible for installing and maintaining ESC practices, a trained and experienced contractor is an important element of an ESC Plan. Trained and experienced staff can save projects time and money through proactive construction and maintenance of ESCs. Staff should be encouraged to become experienced in ESC. Key staff should also be assigned to provide that role, so that the appropriate level of experience and supervision is available for each new project.

9. Adjust the ESC Plan as needed

An effective ESC Plan is modified as a project progresses from bulk earthworks to a fully developed site. Factors such as weather, changes to grade, altered design including drainage and formation of roads can require changes to initial ESC design.

The ESC Plan should be updated to suit site adjustments in time for the pre-construction meeting and initial inspection of installed ESCs. The Plan must also be regularly referred to and available on site. Prior to works commencement, consideration should be given as to how the site will change throughout the project, and how the ESC Plan will need to evolve to reflect this.

Note: For consented sites, adjustments to the ESC Plan may require sign-off from Auckland Council.

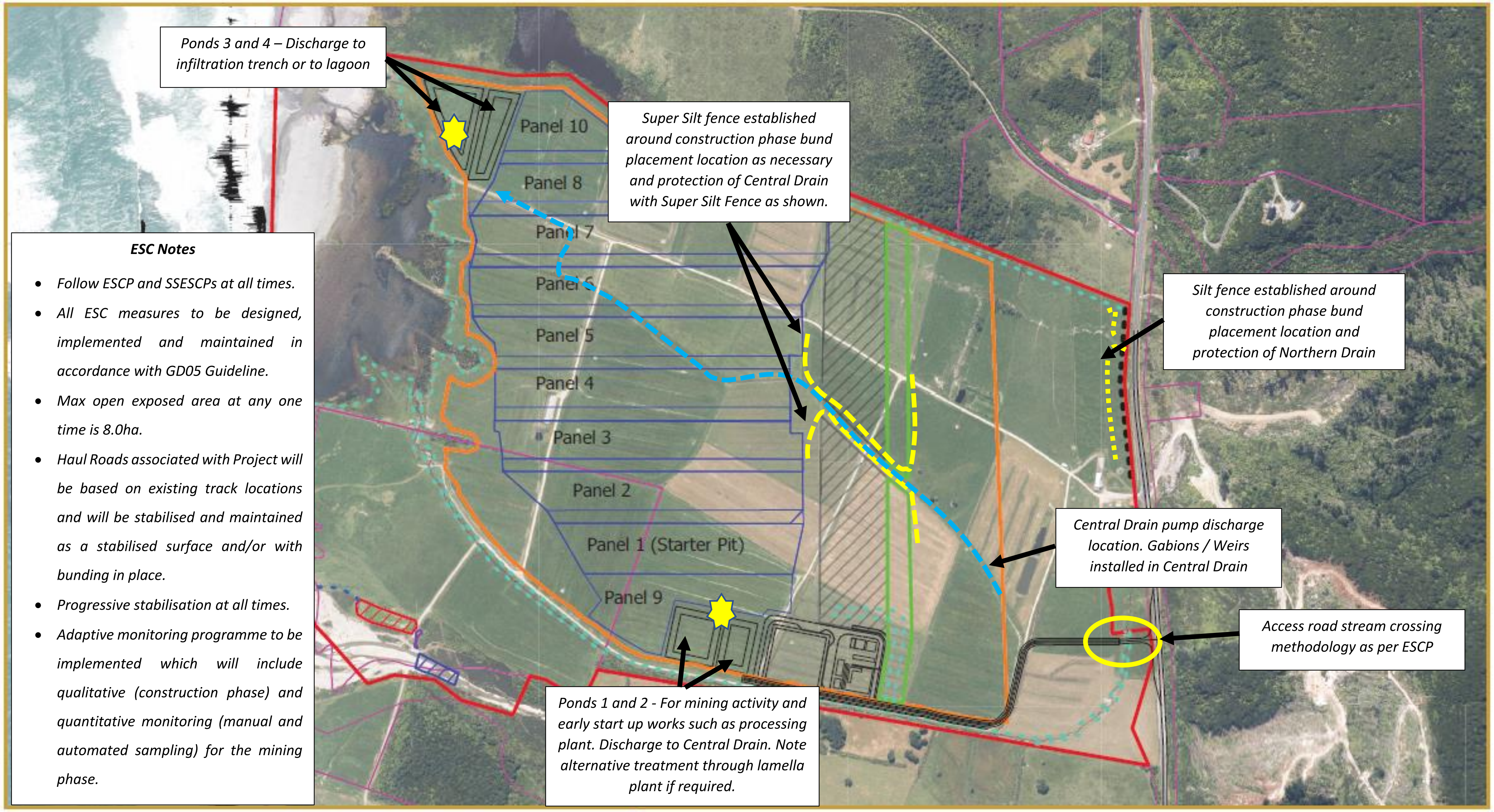
10. Assess and adjust your ESC measures

ESC measures need to be inspected, monitored and maintained.

Inspection and maintenance of controls is especially important prior to and following a storm event. A large or intense storm can leave ESC measures in need of repair, replacement, reinforcement or cleaning out. Maintaining and repairing measures as soon as possible after a storm event will maximise the ongoing efficiency of the measures and minimise adverse environmental effects.

Appendix C. ESC Plan

Barrytown ESCP Overview Concept Plan



Tai Poutini RESOURCES

TiGa Consent Application
Amended Map

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Produced for: TiGa
by Luke McNeish on 12/06/2023

0 125 250 375 m

1:8,000 @ A3

Projection: WSG84 / NZTM2000
Background Imagery: ESRI Satellite
Data Sources: LINZ, Client and or TPRL Data

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- Watertake Location
- Premining ore stockpile
- Mining Disturbance Area
- Mine Infrastructure
- Overflow Channel
- Water Infiltration Area
- Mining Strips
- Bund and Planting
- Property Boundaries
- Automated Sampling Locations

Note: Refer to Landscape Mitigation Plan for detailed Information on Bunds and Planting.

Appendix D. Soil Bench Tests

Barrytown – Sample Testing

Roger Fraser - Water Systems Management - October 2022

Introduction:

Nine dried samples from the Barrytown site were received from NZIMMR for analysis. From these various blends were made to make up samples representative of 1%, 3%, and 6% w/v slurry samples using Nelson tap water.

The dry samples details supplied are shown below:

BATCH	SAMPLE ID	Starting Mass	>2.0mm Mass	<2.0mm, >0.053mm Mass	Captured <0.053mm Mass	Total <0.053mm Mass	Total <0.053mm Mass
		g	g	g	g	g	%
#25	201054	4454	262	3103	874	1089	24.4
#19	201790	3714	4	2755	745	955	25.7
# 31	201315	5249	314	3900	479	1035	19.7
#35	201515	4432	46	4015	357	371	8.4
#36	201691	12388	24	11223	767	1141	9.2
#14	200590	2487	719	1635	116	133	5.3
#30	201288	4746	20	3690	965	1036	21.8
#23	200972	4647	315	3905	339	427	9.2
#10	200435	5461	212	4694	435	555	10.2

The blends chosen for the settling tests are listed in the next table. The "High" slurry was a mixture of Batches #25 and #19. The "Mid" slurry was a mixture of Batches #23 and #10. The "Low" slurry was a mixture of Batches #35 and #14.

Slimes Sample	Blend Mass Total	Blend <0.053mm Mass	Slurry Dilution for Testing	Slurry Dilution for Testing
	g	%	w/v %	g solids / L slurry
"High"	1490	25.1	6	60
"Mid"	678	9.7	3	30
"Low"	232	6.9	1	10

A 10L sample of each slimes sample was prepared based on the following:

- Low 1% Solids Slurry: (#14/#35) 50g of each = 100g/10L tap water
- Mid 3% Solids Slurry: (#10/#23) 150g of each = 300g/10L tap water
- High 6% Solids Slurry: (#19/#25) 300g of each = 600g/10L tap water

All samples were well mixed and left to rehydrate.

Initial test screening work involved three different coagulants and 15 different polymers to assess the best 'recipe' across three manufactured slimes samples.

The first series of tests were based around using a polymer only. After a series of jar tests across the 1% w/v, 3% w/v, and 6% w/v slimes samples a medium/high charge high molecular weight cationic polymer was chosen as the most consistent performer across each sample. A series of settling tests were then carried out on the prepared slurry samples. The 6% w/v samples had a slightly depressed pH level (5.6) which may be an issue if metallic coagulants are required for better clarity.

Test samples were drawn from the top 50mm of the settling cylinder at 5, 10, and 15 minutes and measured for turbidity (FAU – equivalent to NTU) and Total Suspended Solids (TSS) using a spectrophotometer. The final settled volume of slimes was measured at 30 minutes.

1% w/v (6.5 pH)

Time (min)	1% w/v slimes Dose: 1ml 0.2% +ve/L = 2g/m3 or 200g/T solids dose rate		1% w/v slimes Dose: 3ml 0.2% +ve/L = 6g/m3 or 600g/T solids dose rate	
	Turbidity (FAU)	TSS (g/m3)	Turbidity (FAU)	TSS (g/m3)
5	164	201	35	42
10	162	199	36	39
15	148	182	32	34
Settled Sludge Volume (@30min)	**~17mm ~5.2%**		**~15mm ~4.6%**	

Very rapid settling. Approximately 37-40m/hr in the first 30 seconds.

3% w/v (6.9 pH)

Time (min)	3% w/v Dose: 1ml 0.2% +ve/L = 2g/m3 or 67g/T solids dose rate		3% w/v Dose: 3ml 0.2% +ve/L = 6g/m3 or 200g/T solids dose rate	
	Turbidity (FAU)	TSS (g/m3)	Turbidity (FAU)	TSS (g/m3)
5	168	197	111	122
10	152	177	113	118
15	147	146	105	115
Settled Sludge Volume (@30min)	**~22mm ~6.8%**		**~23mm ~7.1%**	

Very rapid settling. Approximately 33-35m/hr in the first 30 seconds.

6% w/v (5.6 pH)

Time (min)	6% w/v Dose: 3ml 0.2% +ve/L = 6g/m3 or 100g/T solids dose rate		6% w/v Dose: 4ml 0.2% +ve/L = 8g/m3 or 133g/T solids dose rate	
	Turbidity (FAU)	TSS (g/m3)	Turbidity (FAU)	TSS (g/m3)
5	239	254	199	215
10	207	223	187	201
15	201	213	170	187
Settled Sludge Volume (@30min)	**~46mm** **~14.2%**		**~42mm** **~12.9%**	

With the slightly slower settling rate with the 6% w/v sample it was possible to produce a standard settling curve. The graphs below shows the settling curves for two dose rates using polymer only.

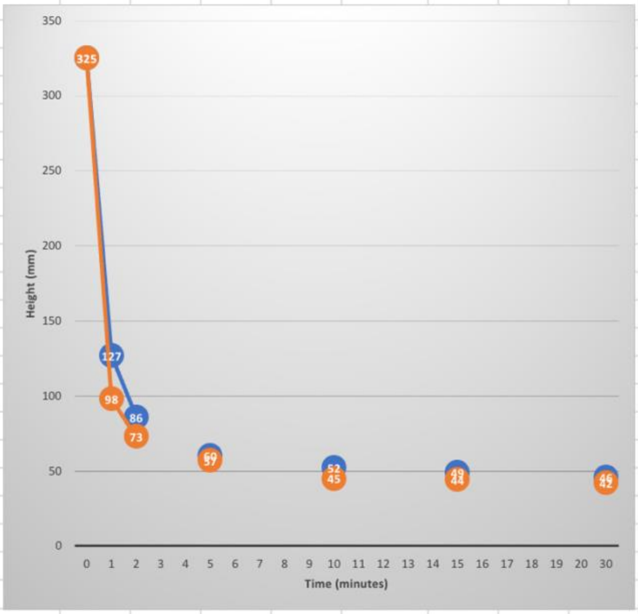
SEDIMENTATION TEST (6% Slimes)

CUSTOMER: TiGa Minerals & Metals | TESTED BY : Roger Fraser

6% Slurry | DATE : October 2022

Coagulant	X	X
Dose (g/m^3)	X	X
Flocculant	7007	7007
Dose (mL/L)	3	4
TIME MINS	HEIGHT MM	HEIGHT MM
0	325	325
1	127	98
2	86	73
3		
4		
5	60	57
6		
7		
8		
9		
10	52	45
11		
12		
13		
14		
15	49	44
16		
17		
18		
19		
20		
30	46	42

NOTES: 6% w/v slimes sample. Dose of polymer only. A cationic powder made to 0.2% w/v.



Notes: Tests completed in a 1L glass measuring cylinder.

Settling Velocity (6% slimes sample):

Settling Velocity		
MINS	3mL dose M/hr	4mL dose M/hr
1	11.9	13.6
2	7.2	7.6
3		
4		
5	3.2	3.2
6		
7		
8		
9		
10	1.6	1.7
11		
12		
13		
14		
15	1.1	1.1
16		
17		
18		
19		
20		
30	0.6	0.6

From this data above I was able to produce the following table showing the settling rate at various stages in metres per hour.

The first two minutes is the Free Settling phase where solids settling rate is not impacted much by other solids.

The middle phase is the Hindered Settling Phase where the solids concentration increases and the particles begin to interact with each other as they settle.

The final phase is the Compaction Phase where the settling has all but stopped and the solids begin to compress.

Water Quality:

As the solids concentration in the samples increased the performance of the polymer reduced in terms of residual water quality. The settling rate was still very good. The turbidity and TSS both increased and additional polymer dose did not improve this much. It was decided to complete some trial work with the addition of a coagulant prior to the polymer. This will be important if there are to be discharges off site where consent conditions will be imposed generally based on Turbidity, TSS, and pH. The tests using coagulants are shown below.

Coagulant addition:

A coagulant can be added prior to the polymer to help improve the settling rate, floc formation, and especially final water quality. The coagulant can also reduce the amount of polymer required. A series of tests using 250mL of the various slimes samples were carried out to see the water quality effect when using coagulants prior to polymer addition.

Three coagulants chosen to be used:

- **PACl** : Polyaluminium chloride (can be affected by low pH)
- **AquaFIX** : Blend of aluminium chlorohydrate (ACH) and polyDADMAC/polyamine
- **L3RC** : polyDADMAC

If low pH in the raw water is an issue (lower than ~6.0 pH) then the PACl performance can be poor. The AquaFIX is less likely to be much affected unless the pH drops very low. The polyDADMAC seems to work well in any pH value expected.

The polymer required after the use of the coagulants was an anionic charged polymer. Polymer consumption is generally reduced when a coagulant is used. Coagulant dosing requires high energy mixing at the dose point and can require some mixing time prior to polymer dosing.

All samples were 250mL and dosed with various coagulants, mixed rapidly, polymer addition followed with low energy flocculant mixing. Samples were settled with Turbidity and TSS samples taken at set times from the top layer of the treated samples. Coagulants used in testing were made to 1% v/v as delivered and polymers where 0.2% w/v.

1% w/v slimes sample (6.5 pH)

1% 250mL Time (min)	PACl 0.25mL + 7014 0.5mL		AquaFix 0.5mL + 7014 0.5mL		L3RC 0.2mL + 7014 0.5mL	
	Turbidity (FAU)	TSS (g/m3)	Turbidity (FAU)	TSS (g/m3)	Turbidity (FAU)	TSS (g/m3)
5	29	39	13	17	42	50
10	27	30	18	19	47	43
15	22	28	11	15	40	48

3% w/v slimes sample (6.9 pH)

3% 250mL Time (min)	PACl 0.5mL + 7014 0.5mL		AquaFix 0.75mL + 7014 0.75mL		L3RC 0.2mL + 7014 0.75mL	
	Turbidity (FAU)	TSS (g/m3)	Turbidity (FAU)	TSS (g/m3)	Turbidity (FAU)	TSS (g/m3)
5	26	24	22	27	35	41
10	15	18	24	28	30	36
15	16	16	17	24	26	34

6% w/v slimes sample (5.6 pH)

6% 250mL Time (min)	PACl 2mL + 7014 0.5mL		AquaFix 0.5mL + 7014 0.25mL		L3RC 0.25mL + 7014 0.25mL	
	Turbidity (FAU)	TSS (g/m3)	Turbidity (FAU)	TSS (g/m3)	Turbidity (FAU)	TSS (g/m3)
5	39	32	40	35	30	31
10	40	41	39	37	28	26
15	29	24	37	38	27	24

Conclusions:

Using a single cationic polymer produces a good robust and a rapid settling floc particle but the quality of the treated water reduces as the solids increased.

Coagulant addition helps with the treated water quality, also produced a good rapid settling floc particle, and reduced the overall polymer consumption. Coagulant addition is an extra cost but can be offset by savings in polymer addition.

Coagulants are liquid and are easily dosed. The polyDADMACs can be very viscous in cooler weather. Polymers comes in powder or emulsion form. Powder is generally the cheapest option with a wider selection but requires reasonable investment in make-down equipment to dissolve the powder and get it to be ready to be dosed. Emulsion polymers are a viscous liquid that can be dosed via an automatic system and only require clean water at good pressure to mix and deliver the polymer to the dose point. Emulsion polymers are generally more expensive than powders and there is a more limited choice of options.

There are samples left and if there is extra work required then this can be carried out.

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Appendix E. CWD Calculations

Clean Water Diversion Sizing Spreadsheet

Project:	**CWD Barrytown**		
Calculations By:	**Graeme Ridley**	**Date:**	**24/11/2022**
Checked By:		**Date:**	
RDE:	**Clean Water Diversion - Generic**		

Step 1 -

C=	0.45		**Assume Worst Case - Hydrogeo Advice**
I =	43.1	mm	**HIRDS Data (20year 60min Intensity)**
A =	10	ha	**(Max Catchment Size)**

Q =	**0.539**	m^3/s	**Design Flow Required**
Q =	**539.18**	l/s	**Design Flow Required**

$Q = .00278CiA$

Step 2 - Determine Diversion Drain Sizing

Cross Section Area =	**0.9519**	m^2
Top Width =	**2.24**	m
Hydraulic Radius =	**0.351**	
Capacity =	**0.547**	m^3/s
Design Flow =	**0.539**	m^3/s

b=	1.1	m
d=	0.57	m
e=	0.57	m (e=d)
Z=	1	

Chanel Slope =	3.00%
n =	0.150

Channel	**OK: Channel Capacity > Design Flow**

Actual Channel Dimensions Required - Including 300 mm Freeboard

b=	**1.1**	**m**
d=	**0.87**	**m**
e=	**0.87**	**m**

Check For Channel Full Velocity (Check against Table 8-4)

V=	**0.57**	**m/s**	**V = Q / A**

Vegetate / Check Dams (50m)

RidleyDunphy

environmental & planning consultants

Rainfall depths (mm) :: Historical Data

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	8.77	12.7	15.7	22.3	31.3	51.8	69.9	93.0	122	142	158	171
2	0.500	9.68	14.0	17.3	24.4	34.1	56.2	75.7	100	131	153	170	184
5	0.200	12.9	18.5	22.7	31.8	44.0	71.4	95.2	125	162	188	207	224
10	0.100	15.4	21.9	26.8	37.3	51.3	82.5	109	143	184	212	234	252
20	0.050	18.1	25.6	31.1	43.1	58.9	93.8	124	161	206	236	260	279
30	0.033	19.7	27.8	33.8	46.7	63.5	101	132	171	218	250	275	295
40	0.025	20.9	29.5	35.7	49.2	66.8	105	138	178	227	260	285	306
50	0.020	21.9	30.8	37.3	51.2	69.4	109	143	184	234	267	293	314
60	0.017	22.7	31.8	38.6	52.9	71.6	112	147	189	240	274	300	321
80	0.013	24.0	33.6	40.6	55.6	75.0	117	153	196	248	283	310	332
100	0.010	25.0	34.9	42.2	57.7	77.7	121	157	202	255	291	318	340
250	0.004	29.4	40.8	49.0	66.5	88.9	137	177	225	282	319	348	372

Annexure B - **Construction Sequence and Earthwork Details - Estimates Only**

Sequence	Activity	Phase of Works	Machinery	Location	Estimated Duration of Works	Area of Disturbance	Volume of Disturbance	Discharge Location	EC Measures to be Utilised
1	Eastern Limit Bunds	Construction	Excavator	North of Central Drain Alongside State Highway with a gap in the bund to allow culvert outfall to remain to Northern Drain	24 days	2.52 ha	63,800 m3	Northern Drain	Silt Fence around Northern Drain and stabilise immediately on completion. Can bund and pump if required.
2	Central Drain	Construction	Excavator	Central Drain	7 days	0.5 ha	0 m3	Discharge into the Lagoon and Northern Drain until the CWF established	Gabions installed within channel. Monitor and erosion protection if required. Once we get to Panel 3 (or earlier if required) establish a new drain and this will have vegetation and protection established as necessary. This will involve a dam and divert and stabilise as necessary with details in SSESCP
3	Clean Water Facility (CWF) and Central Bund	Construction	Excavator & Trucks	North Western Corner	14 days	1.4 ha	Pond 3 (28,100 m3) Pond 4 (36,800 m3)	Water retained within water facility. Topsoil and waste material carted to North -End of Central Bund to provide bunding. Water run off collected and directed to Central Drain.	Progressive stabilisation. When excavating ponds utilise some of the material to form bunds around the ponds. Can utilise silt fences and impoundment if required. Central drain protected with super silt fence
4	Mine Water Facility Construction (MWF) and Central Bund	Construction	Excavator & Trucks	Near Plant Site	14 days	1.05 ha	Pond 1 (32,500 m3) Pond 2 (20,300 m3)	Water retained within water facility. Topsoil and waste material carted to South -End of Central Bund to provide bunding around the plant. Water within the area to be fed back to clean mine water facility. No discharge to Collins Creek.	Utilise Ponds built first. When excavating ponds we will need to utilise some of the material to form bunds around the ponds - the pond vol required is the live vol above the ground water level. Central drain protected with super silt fence.
5	Ore and Waste Dump	Construction	Excavator & Trucks	Commence North End of Ore Dump	28 days	5.3 Ha	Will be the destination of ore and waste material from the CWF, MWF and Pre-Mining Void	All ore from the dams will be carted to the North end of the ore dump - Central next to stockpile. Water run off from this area to be collected and then directed to Central Drain once works completed on CWF and MWF. Haul Roads included.	Existing super silt fence and progressive stabilisation
6	Plant Site	Construction	Excavator, Grader & trucks	Plant Site	28 days	1.9 ha	0 m3	Excess waste and top soil carted to south end of Central Bund. Water directed to MWF	Silt Fence and progressive stabilisation.
7	Access Road	Construction	Excavator, Grader & trucks	From State Highway	14 days	0.55 ha	0 m3	MWF and Central Drain however no discharge into the Collins from access road.	Progressive stabilisation with clean aggregate
8	Pre - Mining Void	Mining	Excavator, Grader & trucks	Panel 1	20 days	3 Ha	137,900 m3	MWF + Central Drain and CWF and if required Filtration System	MWF & CWF